10th Annual Systems Engineering Conference
"Focusing on Improving Performance of Defense Systems Programs"

San Diego, CA
22-25 October 2007

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Agenda

Tuesday, 23 October 2007

Keynote Addresses:

- *Hon James Finley,* Deputy Under Secretary of Defense, Acquisition and Technology
- *Hon Charles McQueary,* Director, Operational Test and Evaluation

Plenary Session: Executive Panel:

- *Mr. Mark Schaeffer,* Director, Office of Under Secretary of Defense of Acquisition, Technology and Logistics; Director, Systems and Software Engineering

Panelists:

- *Mr. Terry Jaggers,* SAF/AQR – Science, Technology, and Engineering
- *Mr. Carl Siel,* Chief Engineer, Office of the Assistant Secretary of the Navy Research, Development and Acquisition
- *Mr. Doug Wiltsie,* HQDA, OASA (ALT)

Track 1

- "Update: OSD Systems Engineering Revitalization Efforts," Col Richard Hoeferkamp, USAF
- "The Effectiveness of Systems Engineering: On Federal (DoD) System Development Programs", Mr. Al Mink, SRA International
- "Tools and Resources to Enable Systems Engineering Improvement," Mr. Michael Kutch, SPAWAR Systems Center Charleston
- "Sound Systems Engineering Assures Proper/Early Producibility", Dr. Thomas Christian, Aeronautical Systems Center
- "Realization of Systems Engineering For the Future", Ms. Karen Bausman, AF Center for Systems Engineering

Track 2

- "Developmental Test & Evaluation Policy Vectors", Ms. Darlene Mosser-Kerner OUSD (AT&L)
- "Test Strategy Done Early Drives Test Planning and Successful Testing", Mr. William Lyders,ASSETT, Inc.
- "Applying Design of Experiments Methodology to Sortie Generation Rate Evaluation", Mr. Joseph Tribble, AVW "Implementing a Systems Engineering Risk Program in a Sustainment Environment", Mr. James Miller, USAF
- "Joint Safety Review Process Study", Ms. Paige Ripini, Booz Allen Hamilton

Track 3

- "DoD Systemic Root Cause Analysis", Mr. Dave Castellano, OUSD (AT&L)
- "Applying Systems Engineering During Pre-Acquisition Activities", Lt Col Mark Wilson, USAF
- "Reforming the DoD Acquisition Process—A Systems Engineering Approach", Mr. Stephan Ward, U.S. Air Force
- "The Effectiveness of Systems Engineering: On Federal System Development Programs", Mr. Alan Mink, SRA International

Track 4

- "Environment, Safety, and Occupational Health (ESOH)—Design Considerations to Support Sustainability and Readiness", Ms. Patricia Huheey, ODUSD (I&E)
- "Real-Time Diagnostics for High Availability Systems", Mr. Edward Beck, Computer Sciences Corporation
- "Sparing Satellites Comparative Strategies of On-orbit & In-factory Storage", Mr. James Mazzei, The Aerospace Corporation

Track 5

- "Acquisition M&S Master Plan Implementation Status", Mr. Michael Truelove, SAIC
- "Establish M&S-Related Guidelines for Solicitations, Source Selections, and Contracting", Mr. Michael Truelove, SAIC
- "Modeling and Simulation Resource Reuse Business Model", Mr. Dennis Shea, Center for Naval Analyses

- “Modeling and Simulation Support Plan”, Mr. David Henry, Lockheed Martin
- “Modeling and Simulation Education for the Acquisition/T&E Workforce: Requirements Analysis”, Mr. David Olwell, NPS

Track 6

- “The Use of Enterprise Architecture to Support the Development of the Next Generation Air Transportation System (NextGen)”, Mr. David Synder, The MITRE Corp.
- “Complex Systems of Systems: The Dual Challenge”, Mr. Phillip Boxer, Software Engineering Institute
- “Systems Engineering in the Cognitive and Social Domains of Net Centric Operations”, Dr. Abe Meilich, Lockheed Martin
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Track 7

- “Simplifying & Scaling Engineering Processes: Unifying Business Units and Engineering Disciplines”, Mr. Raymond Jorgensen, Rockwell Collins
- “NAVAIR Systems Engineering Revitalization”, Mr. Michael Gaydar, Department of Navy, NAVAIR
- “Integrating Engineering Project Management and Product Development Processes”, Mr. Raymond Jorgensen, Rockwell Collins
- “Engineering for System Assurance—Legacy, Life Cycle, Leadership”, Mr. Paul Croll, Computer Sciences Corporation

Track 8

- “DoD Software Engineering and System Assurance”, Ms. Kristen Baldwin, ODUSD (A&T) Systems and Software Engineering
- “The Integrated Software and Systems Engineering Curriculum Project: Creating a Reference Curriculum for Graduate Software Engineering Education”, Ms. Kristen Baldwin, ODUSD (A&T) Systems and Software
- “Requirements for a Chief Software Engineer in a DoD Acquisition Agency”, Mr. Al Florence, The MITRE Corporation
- “Developing an Integrated Process Methodology for Interim Software Releases”, Mr. Tim Woods, Southern Methodist University

Wednesday, 24 October 2007

Track 1

- “Change Management of UML-Based Systems Engineering Artefacts”, Mr. David Price, Eurostep
- “A Day in the Life of a Verification Requirement”, Mr. Stephen Scukanec, Northrop Grumman Corporation
- “How to Measurably Improve Your Requirements”, Mr. Timothy Olson, Lean, Solutions Institute, Inc.
- “Case Studies: A Common Language Between Engineers and Managers”, Capt DeWitt Latimer, USAF
- “A Strategy for Improved System Assurance”, Ms. Kristen Baldwin, ODUSD (A&T) SSE/SSA
- “Discussion of the U.S. Army RDECOM APS Objective Trade Study”, Mr. Frank Salvatore, High Performance Technologies, Inc.
- “Program Support Review Deep Dive”, Mr. Peter Nolte, OUSD/SSE

Track 2

- “An Update on the DT&E Committee’s Recommended Policy Changes to DoD 5000”, Col Richard Stuckey,USAF,OUSD (AT&L)/SSE/ DT&E
- “System Test and Evaluation in the DARPA Immune Building Demonstration Program”, Mr. Mark Saxon,Battelle
- “ Modeling and Simulation in the Navy Warfare Systems Test & Evaluation Enterprise”, Ms. Shala Malone,Navy Program Executive Office Integrated Warfare
- “Joint Mission Environment Test Capability (JMETC)”, Mr. Richard Lockhart, Test Resource Management Center
- “Testing Concept of Operations in DoD’s Net Centric Environment”, Mr. Steve Reeder, South Carolina
- Research Authority (SCRA
- “Do it right, do it early; Do it early, do it right”—Considerations for the Early Stages of Concept, System, and Systems of-Systems Definition”, Mr. Jeff Loren, MTC Technologies, Inc. (SAF/AQRE)
- “Applications of Systems Engineering to Pre-Milestone A Projects”, Ms. Lori Zipes,Naval Surface Warfare Center PC
- “Systems Engineering in a Systems of Systems Environment - Defense Update”, Ms. Kristen Baldwin, ODUSD (A&T) SSE/SSA
- “ASW System-of-Systems Engineering Analysis Applied in an LCS ASW Integration Pilot Project”, Mr. G. Richard Thompson, JHU/APL

Track 3

- “Systems Engineering Plan Preparation Guide Update”, Mr. Chester Bracuto, OSD/AT&L/A&T/SSE/ED
- “ Toward a Unified Systems Engineering Plan”, Mr. Robert Scheurer, Boeing Integrated Defense Systems
- “Integrating Risk & Knowledge Management”, Mr. David Lengyel, NASA
- “Systems Engineering and Program Management—How Different are They?”, Ms. Lori Zipes, Naval Surface Warfare Center PC
- “Systems Engineering Analysis to Improve Concept Development of Complex Defense Systems”, Mr. Michael Harper, SPAWAR Systems Center Charleston
- “ The Joint Partnership Between Program Management and Systems Engineering”, Mr. Samuel Son, The Boeing Company
- “Lockheed Martin Aeronautics Company Approach to Solving Systemic Development Program Issues”, Mr. John Weaver, Lockheed Martin Aeronautics Company
- “Airborne Signals Intelligence Payload (ASIP) Program Integrated Risk Management”, Mr. Danial Bolek, USAF
- “Improvements to the Risk Management Process”, Mr. Doug Atkinson, USAF
- “Integrated Risk and Earned Value Management”, Mr. Paul Davis, Northrop Grumman
- “Application of Risk Management Practices to NNSA Tritium Readiness Subprogram”,Mr. Sham Shete, Washington Savannah River Co.

Track 4

- “Defining Lean Service and Maintenance Processes”, Mr. Timothy Olson, Lean Solutions Institute, Inc.
- “Modeling Integrated Logistics Systems to Support Transformation in the U.S. Coast Guard”, Mr. Patrick Cumby, VectorCSP, L

“Asset-Based PBL for Navy Warships – A Case Study for LCS Class Ships”, Mr. Michael Mahon, Lockheed Martin
- “Integrated Diagnostics Closed Loop Data System (At the Point of Use) (Support Systems Knowledge Engineering Enhances Traditional Support Equipment Systems Engineering),” Mr. Steven Head, Boeing
- “Aging Aircraft Sustainment with Non-Standard Engineering”, Ms. Kendal Hinton, Georgia Tech Research Institute
- “Maintaining System Viability for the Long Term”, Mr. Peter Henry, BAE Systems Land and Armament
- “C-17 Program Applies Systems Engineering to a Large Improvement Project”, Mr. Brent Theodore,The Boeing Company

Track 5

- *“Advancing the FEDEP for Simulation Based Acquisition*”, Dr. Katherine Morse, SAIC
- “Acquisition M&S Community Sponsored M&S Project: Standardized Documentation for Verification, Validation, and Accreditation”, Mr. Kevin Charlow, *(paper) (slides)* Space and Naval Warfare Systems Center Charleston
- “A Methodology for Assessing & Prioritizing the Risks Associated with the Level of Verification, Validation and Accreditation (VV&A) of Models and Simulations”, Dr. James Elele, U.S. Navy
- “Experiences in Applying SysML to Develop Interoperable Torpedo Modeling and Simulation Components”, Mr. Thomas Haley, Naval Undersea Warfare Center
- “Unifying Systems Engineering Simulations”, Mr. Ryan O’Grady, Cybernet Systems Corporation
- “Information Modeling for Systems Integration”, Ms. Claudia Rose,BBII
- “Simulation Supported Decision Making”, (slides1) (slides 2) *Mr. Gene Allen*, MSC Software Corporation

Track 6

- “Achieving Agility in Cyberspace”, Mr. Phillip Boxer, Software Engineering Institute
- “Application of Autonomic Agents for Global Information Grid”, Mr. David Cox, University of Arizona
- “Architecture-Based Concept Evaluation in Support of JCIDS”, Dr. David Jacques,Air Force Institute of Technology
- “System of Systems Implications for Operational Test”, Dr. John Colombi, Air Force Institute of Technology
- “Case Study: Net Centric Mission Thread Modeling and Analysis”, Dr. Prem Jain, MITRE
- “Quantitative Comparison of Alternative Designs for a JC3M System”, Mr. Gregory Miller, Naval Postgraduate School
- “Advanced Net Centric Simulation for Aerospace Command and Control”, Ms. Kimberly Kendall, 753d ELSG/NEM, ESC, USAF

Track 7

- “CMMI—Next Steps”, Ms. Kristen Baldwin, ODUSD (A&T) SSE/SSA
- “CMMI Instructional Challenges to Systems Engineers in Small Settings”, Dr. Mary Anne Herndon, Transdyne Corporation
  “FISMA Operational Controls and Their Relationship to Process Maturity”, Ms. Rhonda Henning, Harris Corporation
- “Executing a Successful CMMI Maturity Level 3 SCAMPI For SPAWAR Systems Center Charleston”, Mr. Michael Kutch, SPAWAR Systems Center Charleston
- “CMMI for Services: Re-Introducing the CMMI for Services Constellation”, Mr. Craig Hollenbach, Northrop Grumman Corporation
- “How to Paint a Room: The Role of Specs & Standards in SE”, Mr. Robert Kuhnen, USAF
- “Continuous Improvement at the Organization, Team, and Individual Levels —Lessons Learned Integrating CMM,TSP, and PSP and Why All Three are Needed”, Mr. Girish Seshagiri,Advanced Information Services, Inc
- “Addressing Environment, Safety and Occupational Health Issues for the Mine Resistant Ambush Protected (MRAP) Vehicle Program”, Ms. Jennifer Malone, EG&G
- “Anatomy of an Award Winning Safety Program: A Case Study of the SSGN OHIO Class Conversion Safety Program”, Mr. Ricky Milnarik, Electric Boat Corporation
- “The Safety of Unmanned Systems: The Process Used to Develop Safety Precepts for Unmanned Systems”, Mr. Mike Demmick, NOSSA

Track 8

- “Defining Software Component Specifications: An Open Approach”, Mr. Kenneth Klein,Computer Sciences Corporation
- “System Engineering and Software Exception Handling (SEH)”, Mr. Herbert Hecht, SoHaR Incorporated
- “A Convergence of Technologies for Better Software NOW!”, Ms. Dorothy Acton, Lockheed Martin IS&GS
- “Identifying Acquisition Patterns of Failure Using System Archetypes”, Mr. William Novak, Software Engineering Institute
- *“Revitalizing Education and Training in Systems Engineering”*, *Dr. Don Gelosh*, Department of Defense, OSD(AT&L)/SSE/ED
- “Customer-Driven, Partnership-Based Systems Engineering Education and Training”, Mr. Jerrell Stracener, Southern Methodist University
- “Application of Systems Engineering Principles in the Design of Acquisition Workforce Curricula”, (paper) (slide) *Dr. David Olwell*, Naval Postgraduate School

Thursday, 25 October 2007

Track 1

- “USAF Type Certification of Commercial Derivative Aircraft”, Mr. Thomas Morgan, USAF
- “Global Positioning System Case Study”, Mr. Randall Bullard, Air Force Center for Systems Engineering

Track 2

- “Implementing the Technology Maturity Vector”, Mr. Joseph Terlizzese, Systems Engineering Support Office
- “Technology Readiness Assessments; Milestone B Certification Requirement for Technologies to be Demonstrated in a Relevant Environment”, Dr. Jay Mandelbaum, Institute for Defense Analyses
- “Meeting Enterprise System Engineering Challenges for the U.S. Next Generation Air Transportation System (NextGen)”, Mr. Jerry Friedman,

The MITRE Corporation

- “Sensor Resource Allocation as a Driver in System Concept Development”, Mr. Ravi Moorthy, Lockheed Martin MS2

Track 3

- “Managing Requirements to Manage Scope in the Case of MUOS”, Ms. Christy Howard, Maxim Systems, Inc.
- “Organizational Leadership and Management Dynamics for Technical Execution in Acquisition Programs”, Mr. Francis Sisti, Aerospace Corporation
- “C-17 Systems Engineering Process to Prioritize Material Improvement Program (MIP) Projects”, Mr. Thomas Condron, USAF (516 AESG/ASC)
- “How to Talk to a Program Manager”, Dr. John Mishler, Software Engineering Institute
- “U.S. Department of Defense (DoD) Approach to Best Practices: Building Evidence for Practice Selection Based on Real Experiences”, Dr. Forrest Shull, Fraunhofer Center Maryland

Track 4

- “Strategic Focus: Reduction of Total Ownership Costs (R-TOC) and Value Engineering (VE)”, Dr. Danny Reed, Institute for Defense Analyses
- “Progress Toward an Empirical Relationships Between Reliability Investments and Life-Cycle Support Cost”, Dr. James Forbes, LMI
- “Innovation Strategies for Affordable Readiness”, Mr. Tom Choinski, Naval Undersea Warfare Center
- “Implementing a Systems Engineering Risk Program in a Sustainment Environment”, Mr. James Miller, USAF
- “Asset-Based PBL for Navy Warships – A case study for LCA Class Ships”, Mike Mahon
- “The Deployment Readiness Service: The Challenges of Implementing a Service Oriented Architecture in a Legacy System Environment”, Mr. George Dalton, USAF

Track 5

- “Aircraft Flight Simulator Acceptance Criteria”, Mr. Dean Carico, NAWCAD PAX
- “Computer Modeling to Solve Problems with the T-38 Propulsion Modernization Program”, Mr. Randall Wimer, USAF – FVB
- “Efficacy of Modeling & Simulation in Defense Life Cycle Engineering”, Mr. Donald Cox, Raytheon Missile Systems
- “Modeling Integrated Logistics Systems to Support Transformation in the U.S. Coast Guard”, Mr. Patrick Cumby, Vector CSP, LLC
- “Generic Sensor Model”, Dr. Stanley Hack, Lockheed Martin MS-2
- “Event Timeline Analysis in Multi Mission Scenarios with System Simulation Models”, Mr. Ravi Moorthy, Lockheed Martin MS2

Track 6

- “Testing Concept of Operations in DoD’s Net Centric Environment”, Mr. Steve Reeder, South Carolina Research Authority (SCRA)
- “Agile Governance for SOA-Based Military Systems of Systems”, Mr. Robert Beck, Villanova University
- “Reducing Acquisition Costs Through Incremental Upgrades by Migrating to SOA”, Mr. Tim Greer, Lockheed Martin Corporation

Track 7

- “The DoD’s Proactive Approach to Emerging Contaminants: Managing Risks Today for Tomorrow’s Warfighter and Mission Readiness”, Dr. Carole LeBlanc, Office of the Deputy Under Secretary of Defense
- *“Safe-Escape Analysis System Safety Engineering Study*”, (paper) (slide) *Mr. David Hall,* SURVICE Engineering Company

Track 8

- “Development of Systems Engineers in the Sensors & SONAR Systems Department”, Mr. Lawrence Lazar,Naval Undersea Warfare Center
- “Systems Engineering and the Art of Seeing”, Dr. Robert Monson, Lockheed Martin Corporation
- “Understanding Social Networks-A Key Requirement for System Engineers”, Mr. Karl Selke, Systems Engineering Analyst, Evidence Based Research, Inc.

NDIA
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10th ANNUAL SYSTEMS ENGINEERING CONFERENCE

HYATT REGENCY MISSION BAY • SAN DIEGO, CA

OCT. 22 - 25, 2007

WWW.NDIA.ORG/MEETINGS/8870

Event # 8870

Conference Agenda {At A Glance}

Sunday, October 21, 2007

5:00 pm - 7:00 pm	Registration for Tutorials and General Conference *(Tutorials are an additional $225.00 registration fee)*

Monday, October 22, 2007

7:00 am - 6:00 pm	Registration
7:00 am - 8:00 am	Continental Breakfast for Tutorial Attendees ONLY *(Tutorials are an additional $225.00 registration fee)*
8:00 am - 11:45 am	Tutorial Tracks *(Please refer to pages 4-5 for Tutorial schedule)*
12:00 pm - 1:00 pm	Lunch for Tutorial Attendees ONLY
1:00 pm - 5:00 pm	Tutorial Tracks Continued
5:00 pm - 6:00 pm	Reception in the Regatta Pavilion (Open to All Participants)

Tuesday, October 23, 2007

7:15 am - 6:30 pm	Registration
7:15 am - 8:15 am	Continental Breakfast
8:15 am - 8:30 am	Introductions & Opening Remarks: *Mr. Sam Campagna, Director, Operations, NDIA* *Mr. Bob Rassa, Director, Systems Supportability, Raytheon,* *Chair, Systems Engineering Division, NDIA*
8:30 am - 9:45 am	Keynote Addresses: *HON James Finley, Deputy Under Secretary of Defense, Acquisiton & Technology* *HON Charles McQueary, Director, Operational Test & Evaluation*
9:45 am - 10:00 am	Break

10:00 am - 12:00 pm	Plenary Session: Executive Panel
	Moderator: *Mr. Mark Schaeffer, Director, Office of Under Secretary of Defense for Acquisition, Technology and Logistics; Director, Systems and Software Engineering*
	Panelists: *Mr. Terry Jaggers, SAF/AQR - Science, Technology, and Engineering* *Mr. Carl Siel, Chief Engineer, Office of the Assistant Secretary of the Navy Research, Development and Acquisition* *Mr. Doug Wiltsie, HQDA, OASA (ALT)*
12:00 pm - 1:30 pm	Luncheon with Speaker in the Regatta Pavilion *Mr. Mike Kern, Senior Systems Engineer, OASD (NII)*
1:30 pm - 5:00 pm	Concurrent Sessions *(Please refer to pages 6-10 for session schedule)*
5:00 pm - 6:30 pm	Reception in the Regatta Pavilion

Wednesday, October 24, 2007

7:00 am - 5:00 pm	Registration
7:00 am - 8:00 am	Continental Breakfast
8:00 am - 12:00 pm	Concurrent Sessions *(Please refer to pages 6-10 for session schedule)*
12:00 pm - 1:30 pm	Awards Luncheon in the Regatta Pavilion
1:30 pm - 5:00 pm	Concurrent Sessions *(Please refer to pages 6-10 for session schedule)*

Thursday, October 25, 2007

7:00 am - 3:00 pm	Registration
7:00 am - 8:00 am	Continental Breakfast
8:00 am - 12:00 pm	Concurrent Sessions *(Please refer to pages 6-10 for session schedule)*
12:00 pm - 1:00 pm	Luncheon in the Regatta Pavilion
1:00 pm - 3:00 pm	Concurrent Sessions *(Please refer to pages 6-10 for session schedule)*
3:00 pm	Conference Adjourns

Tutorial Sessions - Monday, October 22, 2007

7:00 am Registration & Continental Breakfast

8:00 am - 9:45 am

Room	Track	Session
Bayview A	Track 1 Tutorial Session 1A1	5305 - Are we Ready for CMMI®? If not, Let's Fix Ourselves *Mr. Al Florence, The MITRE Corporation*
Bayview B	Track 2 Tutorial Session 1A2	5454 - Cost As an Independent Variable and Trade Studies *Mr. Ed Casy, Raytheon Missile Systems*
Bayview C	Track 3 Tutorial Session 1A3	5404 - How to Reduce Schedule Uncertainty by Integrating Sound Management Methods with Systems Engineering Best Practices *Mr. Gary Langford, The Naval Postgraduate School*
Mission I	Track 4 Tutorial Session 1A4	5498 - System Verification Organization *Mr. Jeffrey Grady, JOG System Engineering, Inc.*
Mission II	Track 5 Tutorial Session 1A5	
Mission III	Track 6 Tutorial Session 1A6	5542 - Best-In-Class Early Defect Detection and Defect Prevention *Mr. Timothy Olson, Lean Solutions Institute, Inc.*
Palm I	Track 7 Tutorial Session 1A7	5784 - Operational Concepts: Using Cases & Scenarios to Understand User's Needs *Mr. Raymond Jorgensen, Rockwell Collins*
Palm II	Track 8 Tutorial Session 1A8	5577 - Introduction to SysML & Object Oriented Systems Engineering Methodology (OOSEM) *Mr. Abe Meilich, Lockheed Martin*

Break

10:15 am - 11:45 am

Room	Track	Session
Bayview A	Track 1 Tutorial Session 1B1	5305 - Are we Ready for CMMI®? If not, Let's Fix Ourselves (Cont'd) *Mr. Al Florence, The MITRE Corporation*
Bayview B	Track 2 Tutorial Session 1B2	5454 - Cost As an Independent Variable and Trade Studies (Cont'd) *Mr. Ed Casy, Raytheon Missile Systems*
Bayview C	Track 3 Tutorial Session 1B3	5404 - How to Reduce Schedule Uncertainty by Integrating Sound Management Methods with Systems Engineering Best Practices (Cont'd) *Mr. Gary Langford, The Naval Postgraduate School*
Mission I	Track 4 Tutorial Session 1B4	5498 - System Verification Organization (Cont'd) *Mr. Jeffrey Grady, JOG System Engineering, Inc.*
Mission II	Track 5 Tutorial Session 1B5	
Mission III	Track 6 Tutorial Session 1B6	5542 - Best-In-Class Early Defect Detection and Defect Prevention (Cont'd) *Mr. Timothy Olson, Lean Solutions Institute, Inc.*
Palm I	Track 7 Tutorial Session 1B7	5784 - Operational Concepts: Using Cases & Scenarios to Understand User's Needs (Cont'd) *Mr. Raymond Jorgensen, Rockwell Collins*
Palm II	Track 8 Tutorial Session 1B8	5577 - Introduction to SysML & Object Oriented Systems Engineering Methodology (OOSEM) (Cont'd) *Mr. Abe Meilich, Lockheed Martin*

Buffet Lunch

1:00 pm - 2:45 pm

Track 1 Tutorial Session 1C1	5307 - Requirements Development and Management *Mr. Al Florence, The MITRE Corporation*
Track 2 Tutorial Session 1C2	5326 - Integrating Systems Engineering with Earned Value Management *Mr. Paul Solomon, Performance-Based Earned Value®*
Track 3 Tutorial Session 1C3	5404 - How to Reduce Schedule Uncertainty by Integrating Sound Management Methods with Systems Engineering Best Practices (Cont'd) *Mr. Gary Langford, The Naval Postgraduate School*
Track 4 Tutorial Session 1C4	5511 - Modeling Sustainment and Risk Mitigation for Net-Enabled Realities *Mr. Philip Boxer, Software Engineering Institute/CMU*
Track 5 Tutorial Session 1C5	5540 - Introduction to Reliability Analysis *Dr. Meng-Lai Yin, Raytheon Company*
Track 6 Tutorial Session 1C6	5544 - How to Define Practical Systems Engineering Metrics *Mr. Timothy Olson, Lean Solutions Institute, Inc.*
Track 7 Tutorial Session 1C7	5582 - Leading Effective System of Systems (SoS) Technical Reviews *Mr. David Walden, Sysnovation, LLC*
Track 8 Tutorial Session 1C8	5577 - Introduction to SysML & Object Oriented Systems Engineering Methodology (OOSEM) *Dr. Abe Meilich, Lockheed Martin*

Break

3:15 pm - 5:00 pm

Track 1 Tutorial Session 1D1	5307 - Requirements Development and Management (Cont'd) *Mr. Al Florence, The MITRE Corporation*
Track 2 Tutorial Session 1D2	5326 - Integrating Systems Engineering with Earned Value Management (Cont'd) *Mr. Paul Solomon, Performance-Based Earned Value®*
Track 3 Tutorial Session 1D3	5404 - How to Reduce Schedule Uncertainty by Integrating Sound Management Methods with Systems Engineering Best Practices (Cont'd) *Mr. Gary Langford, The Naval Postgraduate School*
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Track 7 Tutorial Session 1D7	5582 - Leading Effective System of Systems (SoS) Technical Reviews (Cont'd) *Mr. David Walden, Sysnovation, LLC*
Track 8 Tutorial Session 1D8	5577 - Introduction to SysML & Object Oriented Systems Engineering Methodology (OOSEM) (Cont'd) *Dr. Abe Meilich, Lockheed Martin*

5:00 pm - 6:00 pm Reception in Regatta Pavilion

Tuesday, October 23, 2007

1:30 pm - 3:00 pm — concurrent sessions

Room	Track	Paper 1	Paper 2	Paper 3
Bayview A	TRACK 1 *Systems Engineering Effectiveness* Session 2C1	5378 - DoD's Systems Engineering Revitalization Efforts—An Update *Col Richard Hoeferkamp, USAF*	5399 - The Effectiveness of Systems Engineering: on Federal (DoD) System Development Programs *Mr. Al Mink, SRA International*	
Bayview B	TRACK 2 *Test & Evaluation in Systems Engineering* Session 2C2	5503 - A Vector Check—Revitalizing DT&E *Mr. Chris DiPetto, OUSD (AT&L)*	5402 - A Test Strategy Done Early Drives Test Planning and Successful Testing *Mr. William Lyders, ASSETT, Inc.*	
Bayview C	TRACK 3 *Program Management* Session 2C3	5522 - Systemic Root Cause Analysis of Acquisition Program Issues *Mr. Dave Castellano, OUSD (AT&L)*	Systemic Root Cause Analysis - Emerging Recommendations Industry Panel Discussion *Mr. Dave Castellano, OUSD (AT&L)*	
Mission I	TRACK 4 *Integrated Diagnostics* Session 2C4	5797 - Environment, Safety, and Occupational Health (ESOH)—Design Considerations to Support Sustainability and Readiness *Ms. Patricia Huheey, ODUSD (I&E)*	5508 - Integrated Structural Health Monitoring System Using Lamb Waves *Maj Joerg Walter, USAF, Air Force Institute of Technology*	
Mission II	TRACK 5 *Modeling & Simulation* Session 2C5	5446 - Implementing the Acquisition M&S Master Plan *Mr. Michael Truelove, SAIC*	5421 - M&S-Related Guidelines for Contracting *Mr. Michael Truelove, SAIC*	5606 - M&S Planning and Employment Best Practices *Mr. James Hollenbach. Simulation Strategies, Inc.*
Mission II	TRACK 6 *Net Centric Operations* Session 2C6	5430 - The Use of Enterprise Architecture to Support the Development of the Next Generation Air Transportation System (NextGen) *Mr. David Synder, The MITRE Corp.*	5500 - Complex Systems of Systems: The Dual Challenge *Mr. Phillip Boxer, Software Engineering Institute*	
Palm I	TRACK 7 *Best Practices & Standardization* Session 2C7	5780 - Simplifying & Scaling Engineering Processes: Unifying Business Units and Engineering Disciplines *Mr. Raymond Jorgensen, Rockwell Collins*	5491 - Systems Engineering Process Improvements at NAVAIR *Mr. Michael Gaydar, Department of Navy, NAVAIR*	
Palm II	TRACK 8 *Software* Session 2C8	6163 - DoD Software Engineering and System Assurance *Ms. Kristen Baldwin, ODUSD (A&T) Systems and Software Engineering*	6164 - A Reference Curriculum for Software Engineering Graduate Education *Ms. Kristen Baldwin, ODUSD (A&T) Systems and Software Engineering*	

Break in the Regatta Pavilion

3:30 pm - 5:00 pm — concurrent sessions

Track	Paper 1	Paper 2	Paper 3
TRACK 1 *Systems Engineering Effectiveness* Session 2D1	5484 - Tools and Resources to Enable Systems Engineering Improvement *Mr. Michael Kutch, SPAWAR Systems Center Charleston*	5626 - Good Systems Engineering Insures Good Producibility *Dr. Thomas Christian, Aeronautical Systems Center*	5405 - Systems Engineering Realization for the Future *Ms. Karen Bausman, AF Center for Systems Engineering*
TRACK 2 *Test & Evaluation in Systems Engineering* Session 2D2	5489 - Applying Design of Experiments Methodology to Sortie Generation Rate Evaluation *Mr. Joseph Tribble, AVW Technologies*	5774 - Implementing and Measuring Test Program in a Sustainment Environment *Mr. James Miller, USAF*	*Joint Safety Review Process Study* *Ms. Paige Ripini, Booz Allen Hamilton*
TRACK 3 *Program Management* Session 2D3	5779 - Applying Systems Engineering Dring Pre- Acquisition Activities *Lt Col Mark Wilson, USAF*	5435 - Reforming the DoD Acquisition Process—A Systems Engineering Approach *Mr. Stephan Ward, U.S. Air Force*	5365 - PValue of Systems Engineering: Analysis & Results from Previous and Current Studies of Over 100 System Development Projects *Mr. Alan Mink, SRA International*
TRACK 4 *Integrated Diagnostics* Session 2D4	5368 - Real-Time Diagnostics for High Availability Systems *Mr. Edward Beck, Computer Sciences Corporation*	5271 - Leveraging EMS for Condition Based Maintenance *Mr. Bob Heilman, O'Neil & Associates, Inc.*	5287 - Sparing Satellites- Comparitive Strategies of In-orbit & In-factory Storage *Mr. James Mazzei, The Aerospace Corporation*
TRACK 5 *Modeling & Simulation* Session 2D5	5427 - Modeling and Simulation Resource Reuse Business Model *Mr. Dennis Shea, Center for Naval Analyses*	5603 - Modeling and Simulation Support Plan *Mr. David Henry, Lockheed Martin*	6099 - Modeling and Simulation Education for the Acquistion Workforce: Requirements Analysis *Mr. David Olwell, NPS*
TRACK 6 *Net Centric Operations* Session 2D6	5576 - Systems Engineering in the Cognitive and Social Domains of Net Centric Operations *Dr. Abe Meilich, Lockheed Martin*	Global Information Grid (GIG) Technical Foundation (GTF) and GIG Compliance Assessment (GICA) *Mr. Brendan Goode, Booz Allen Hamilton*	Global Information Grid (GIG) Performance Assessment Framework *Mr. Tony Modelfino, Stratogis*
TRACK 7 *Best Practices & Standardization* Session 2D7	5781 - Integrating Engineering Project Management and Product Development Processes *Mr. Raymond Jorgensen, Rockwell Collins*	5831 - Engineering for System Assurance—Legacy, Life Cycle, Leadership *Mr. Paul Croll, Computer Sciences Corporation*	
TRACK 8 *Software* Session 2D8	5315 - Requirements for a Chief Software Engineering in a DoD Acquisition Agency *Mr. Al Florence, The MITRE Corporation*	5481 - Developing an Integrated Process Methodology for Interim Software Releases *Mr. Tim Woods, Southern Methodist University*	

5:00 pm - 6:00 pm Reception in the Regatta Pavilion

Wednesday, October 24, 2007

8:00 am - 9:45 am

concurrent sessions

Room	Track	Presentations		
Bayview A	TRACK 1 *Systems Engineering Effectiveness* Session 3A1	5824 - Change Management of UML-Based Systems Engineering Artefacts *Mr. David Price, Eurostep*	5806 - Investigating the Use of SysML on the FBX-T Radar Program *Mr. Chad Schuyler, Raytheon*	5536 - A Day in the Life of a Verification Requirement *Mr. Stephen Scukanec, Northrop Grumman Corporation*
Bayview B	TRACK 2 *Test & Evaluation in Systems Engineering* Session 3A2	5812 - An Update on the DT&E Committee's Recommended Policy Changes to DoD 5000 *Col Richard Stuckey, USAF, OUSD (AT&L)/SSE/DT&E*	5520 - System Test and Evaluation in the DARPA Immune Building Demonstration Program *Mr. Mark Saxon, Battelle*	5553 - Modeling and Simulation in the Navy Warfare Systems Test & Evaluation Enterprise *Ms. Shala Malone, Navy Program Executive Office Integrated Warfare*
Bayview C	TRACK 3 *Program Management* Session 3A3	5523 - Systems Engineering Plan Preparation Guide Update *Mr. Chester Bracuto, OSD/AT&L/A&T/SSE/ED*	5525 - Toward a Unified Systems Engineering Plan *Mr. Robert Scheurer, Boeing Integrated Defense Systems*	5587 - Integrating Risk & Knowledge Management *Mr. David Lengyel, NASA*
Mission I	TRACK 4 *Integrated Diagnostics* Session 3A4	5546 - Defining Lean Service and Maintenance Processes *Mr. Timothy Olson, Lean Solutions Institute, Inc.*	5355 - Modeling Integrated Logistics Systems to Support Transformation in the U.S. Coast Guard *Mr. Patrick Cumby, VectorCSP, LLC*	
Mission II	TRACK 5 *Modeling & Simulation* Session 3A5	5614 - Live Virtual Constructive (LVC) Architecture Interoperability Assessment *Mr. Warren Bizub, USJFCOM*	5538 - Advancing the FEDEP for Simulation Based Acquisition *Dr. Katherine Morse, SAIC*	
Mission III	TRACK 6 *Net Centric Operations* Session 3A6	5497 - Achieving Agility in Cyberspace *Mr. Phillip Boxer, Software Engineering Institute*	5815 - Distributed Firewalls *Mr. Alejandro Gastelum, Northrop Grumman*	
Palm I	TRACK 7 *Best Practices & Standardization* Session 3A7	5592 - CMMI—Next Steps *Ms. Kristen Baldwin, ODUSD (A&T) SSE/SSA*	5743 - CMMI Instructional Challenges to Systems Engineers in Small Settings *Dr. Mary Anne Herndon, Transdyne Corporation*	
Palm II	TRACK 8 *Software* Session 3A8	5526 - Defining Software Component Specifications: An Open Approach *Mr. Kenneth Klein, Computer Sciences Corporation*	5676 - System Engineering and Software Exception Handling (SEH) *Mr. Herbert Hecht, SoHaR Incorporated*	

Break in the Regatta Pavilion

10:15 am - 12:00 pm

concurrent sessions

Track	Presentations		
TRACK 1 *Systems Engineering Effectiveness* Session 3B1	5557 - How to Measurably Improve Your Requirements *Mr. Timothy Olson, Lean Solutions Institute, Inc.*	5670 - Review of the Roles of a System Architect *Dr. Dinesh Verma, Stevens Institute of Technology*	5865 - Case Studies: A Common Language Between Engineers and Managers *Capt DeWitt Latimer, USAF*
TRACK 2 *Test & Evaluation in Systems Engineering* Session 3B2	5473 - Joint Mission Environment Test Capability (JMETC) *Mr. Richard Lockhart, Test Resource Management Center*	5585 - Testing Concept of Operations in DoD's Net Centric Environment *Mr. Steve Reeder, South Carolina Research Authority (SCRA)*	
TRACK 3 *Program Management* Session 3B3	5381 - Systems Engineering and Program Management—How Different are They? *Ms. Lori Zipes, Naval Surface Warfare Center PC*	5799 - Systems Engineering Analysis to Improve Concept Development of Complex Defense Systems *Mr. Michael Harper, SPAWAR Systems Center Charleston*	5531 - The Joint Partnership Between Program Management and Systems Engineering *Mr. Samuel Son, The Boeing Company*
TRACK 4 *Logistics, Supportability, and Readiness* Session 3B4	5903 - Asset-Based PBL for Navy Warships – A Case Study for LCS Class Ships *Mr. Michael Mahon, Lockheed Martin*	5530 - Considerations & Propose Approach for Integrating New Hardware & Software into the Legacy Military Aircraft Avionics Systems—A Systems Engineering Lesson-Learned Perspective on the C-17 Program *Mr. Phat Vu, The Boeing Company*	5954 - Integrated Diagnostics Closed Loop Data System (At the Point of Use) (Support Systems Knowledge Engineering Enhances Traditional Support Equipment Systems Engineering) Mr. Steven Head, Boeing
TRACK 5 *Modeling & Simulation* Session 3B5	5431 - Acquisition M&S Community Sponsored M&S Project: Standardized Documentation for Verification, Validation, and Accreditation *Mr. Kevin Charlow, Space and Naval Warfare Systems Center Charleston*	5426 - A Methodology for Assessing & Prioritizing the Risks Associated with the Level of Verification, Validation and Accreditation (VV&A) of Models and Simulations *Dr. James Elele, U.S. Navy*	
TRACK 6 *Net Centric Operations* Session 3B6	5386 - Application of Autonomic Agents for Global Information Grid *Mr. David Cox, University of Arizona*	5847 - Architecture-Based Concept Evaluation in Support of JCIDS *Dr. David Jacques, Air Force Institute of Technology*	
TRACK 7 *Best Practices & Standardization* Session 3B7	5808 - FISMA Operational Controls and Their Relationship to Process Maturity *Ms. Rhonda Henning, Harris Corporation*	5485 - Executing a Successful CMMI Maturity Level 3 SCAMPI For SPAWAR Systems Center Charleston *Mr. Michael Kutch, SPAWAR Systems Center Charleston*	CMMI for Services: Re-Introducing the CMMI for Services Constellation *Mr. Craig Hollenbach, Northrop Grumman Corporation*
TRACK 8 *Software* Session 3B8	5764 - A Convergence of Technologies for Better Software NOW! *Ms. Dorothy Acton, Lockheed Martin IS&GS*	5803 - Identifying Acquisition Patterns of Failure Using System Archetypes *Mr. William Novak, Software Engineering Institute*	

12:00 pm Lunch in the Regatta Pavilion

Wednesday, October 24, 2007

concurrent sessions — 1:30 pm - 3:00 pm

Room	Track		
Bayview A	TRACK 1 *Systems Engineering Effectiveness* Session 3C1	5594 - Handbook on Engineering for System Assurance *Ms. Kristen Baldwin, ODUSD (A&T) SSE/SSA*	5805 - A Pragmatic Approach for Defining and Utilizing System States and Modes *Mr. Mark Minnucci, Raytheon*
Bayview B	TRACK 2 *Systems Engineering Effectiveness* Session 3C2	5464 - "Do it right, do it early; Do it early, do it right"—Considerations for the Early Stages of Concept, System, and Systems-of-Systems Definition *Mr. Jeff Loren, MTC Technologies, Inc. (SAF/AQRE)*	5380 - Applications of Systems Engineering to Pre-Milestone A Projects *Ms. Lori Zipes, Naval Surface Warfare Center PC*
Bayview C	TRACK 3 *Program Management* Session 3C3	5795 - Lockheed Martin Aeronautics Company Approach to Solving Systemic Development Program Issues *Mr. John Weaver, Lockheed Martin Aeronautics Company*	5450 - Airborne Signals Intelligence Payload (ASIP) Program Integrated Risk Management *Mr. Danial Bolek, USAF*
Mission I	TRACK 4 *Logistics, Supportability, and Readiness* Session 3C4	5843 - Aging Aircraft Sustainment with Non-Standard Engineering *Ms. Kendal Hinton, Georgia Tech Research Institute*	5477 - M109 Howitzer Sustainment *Mr. Peter Henry, BAE Systems Land and Armaments*
Mission II	TRACK 5 *Modeling & Simulation* Session 3C5	5740 - Leveraging the Integrated Engineering Model (IEM) Process as a Lead Systems Integrator *Mr. Anthony Montano, Raytheon Company*	5376 - Experiences in Applying SysML to Develop Interoperable Torpedo Modeling and Simulation Components *Mr. Thomas Haley, Naval Undersea Warfare Center*
Mission III	TRACK 6 *Net Centric Operations* Session 3C6	5848 - System of Systems Implications for Operational Test *Dr. John Colombi, Air Force Institute of Technology*	5519 - Case Study: Net Centric Mission Thread Modeling and Analysis *Dr. Prem Jain, MITRE*
Palm I	TRACK 7 *Best Practices & Standardization* Session 3C7	5760 - How to Paint a Room: The Role of Specs & Standards in SE *Mr. Robert Kuhnen, USAF*	5837 - Continuous Improvement at the Organization, Team, and Individual Levels—Lessons Learned Integrating CMM, TSP, and PSP and Why All Three are Needed *Mr. Girish Seshagiri, Advanced Information Services, Inc.*
Palm II	TRACK 8 *Education & Training* Session 3C8	5350 - Revitalizing Education and Training in Systems Engineering *Dr. Don Gelosh, Department of Defense, OSD(AT&L)/SSE/ED*	5501 - Customer-Driven, Partnership-Based Systems Engineering Education and Training *Mr. Jerrell Stracener, Southern Methodist University*

Break in the Regatta Pavilion

concurrent sessions — 3:30 pm - 5:15 pm

Track			
TRACK 1 *Systems Engineering Effectiveness* Session 3D1	5433 - A Practical Application of Structured System Engineering and Failure Mode Effects Analysis to New Technologies *Mr. Paul Deniston, Ford Motor Company*	5505 - Discussion of the U.S. Army RDECOM APS Objective Trade Study *Mr. Frank Salvatore, High Performance Technologies, Inc.*	A Deep Dive into Program Review Findings *Mr. Peter Nolte, OUSD/SSE*
TRACK 2 *Systems Engineering Effectiveness* Session 3D2	5593 - Systems Engineering in a Systems of Systems Environment - Defense Update *Ms. Kristen Baldwin, ODUSD (A&T) SSE/SSA*	5602 - ASW System-of-Systems Engineering Analysis Applied in an LCS ASW Integration Pilot Project *Mr. G. Richard Thompson, JHU/APL*	5832 - A Brigade Capability Approach to the Evolution of Current Ground Combat Systems *Ms. Roberta Desmond, U.S. Army*
TRACK 3 *Program Management* Session 3D3	5434 - Improvements to the Risk Management Process *Mr. Doug Atkinson, USAF*	5388 - Integrated Risk and Earned Value Management *Mr. Paul Davis, Northrop Grumman*	5800 - Application of Risk Management Practices to NNSA Tritium Readiness Subprogram *Mr. Sham Shete, Washington Savannah River Co.*
TRACK 4 *Logistics, Supportability, and Readiness* Session 3D4	5528 - C-17 Program Applies Systems Engineering to a Large Improvement Project *Mr. Brent Theodore, The Boeing Company*	5854 - Effective Time on Station (ETOS): The Persistent Performance Metric for Aircraft Systems *Mr. Christopher Marchefsky, NAVAIR*	
TRACK 5 *Modeling & Simulation* Session 3D5	5835 - Unifying Systems Engineering Simulations *Mr. Ryan O'Grady, Cybernet Systems Corporation*	5409 - Information Modeling for Systems Integration *Ms. Claudia Rose, BBII*	5575 - Simulation Supported Decision Making *Mr. Gene Allen, MSC Software Corporatiton*
TRACK 6 *Net Centric Operations* Session 3D6	5407 - Quantitative Comparison of Alternative Designs for a JC3M System *Mr. Gregory Miller, Naval Postgraduate School*	5445 - Advanced Net Centric Simulation for Aerospace Command and Control *Ms. Kimberly Kendall, 753d ELSG/NEM, ESC, USAF*	
TRACK 7 *System Safety* Session 3D7	Addressing Environment, Safety and Occupational Health Issues for the Mine Resistant Ambush Protected (MRAP) Vehicle Program *Ms. Jennifer Malone, EG&G*	Anatomy of an Award Winning Safety Program: A Case Study of the SSGN OHIO Class Conversion Safety Program *Mr. Ricky Milnarik, Electric Boat Corporation*	The Safety of Unmanned Systems: The Process Used to Develop Safety Precepts for Unmanned Systems *Mr. Mike Demmick, NOSSA*
TRACK 8 *Education & Training* Session 3D8	5873 - Reference Curriculum for a Graduate Program in Systems Engineering *Dr. Rashmi Jain, Stevens Institute of Technology*	5522 - Application of Systems Engineering Principles in the Design of Acquisition Workforce Curricula *Dr. David Olwell, Naval Postgraduate School*	5438 - Autopsy of A Good Systems Engineer – An Endangered Species *Mr. Jimmy Thai, SAIC*

Thursday, October 25, 2007

8:00 am - 9:45 am — concurrent sessions

Room	Session			
Bayview A	TRACK 1 *Systems Engineering Effectiveness* Session 4A1	5499 - A Robust Process for Resolving Interface Design Issues in the Complex Concurrent LCS System Engineering Environment *Mr. William Traganza, NAVSEA PMS 485*	5785 - UAI Increasing Flexibility Through Data Driven Interfaces *Mr. Jonathon Miller, USAF —Aeronautical Systems Center*	5785 - Describing Flexibility as an Operational Capability *Mr. Oren Edwards, USAF —Aeronautical Systems Center*
Bayview B	TRACK 2 *Systems Engineering Effectiveness* Session 4A2	5675 - Implementing the Technology Maturity Vector *Mr. Joseph Terlizzese, Systems Engineering Support Office*	5443 - Technology Readiness Assessments; Milestone B Certification Requirement for Technologies to be Demonstrated in a Relevant Environment *Dr. Jay Mandelbaum, Institute for Defense Analyses*	5453 - Meeting Enterprise System Engineering Challenges for the U.S. Next Generation Air Transportation System (NextGen) *Mr. Jerry Friedman, The MITRE Corporation*
Bayview C	TRACK 3 *Program Management* Session 4A3	5849 - Managing Requirements to Manage Scope in the Case of MUOS *Ms. Christy Howard, Maxim Systems, Inc.*	5867 - Organizational Leadership and Management Dynamics for Technical Execution in Acquisition Programs *Mr. Francis Sisti, Aerospace Corporation*	5532 - Systems Engineering Approach to Prioritize Projects *Mr. Thomas Condron, USAF (516 AESG/ASC)*
Mission I	TRACK 4 *Logistics, Supportability, and Readiness* Session 4A4	5419 - DoD/OSD Sustainment/ Readiness Initiatives: Reduction of Total Ownership Costs (R-TOC) and Value Engineering (VE) *Dr. Danny Reed, Institute for Defense Analyses*	5629 - Relating Investment in Reliability Engineering to Reliability Improvement and Reduction of Total Ownership Cost *Dr. James Forbes, LMI*	5493 - Innovation Strategies for Affordable Readiness *Mr. Tom Choinski, Naval Undersea Warfare Center*
Mission II	TRACK 5 *Modeling & Simulation* Session 4A5	5444 - Aircraft Flight Simulator Acceptance Criteria *Mr. Dean Carico, NAWCAD PAX*	5829 - Computer Modeling to Solve Problems with the T-38 Propulsion Modernization Program *Mr. Randall Wimer, USAF - FVB*	
Mission III	TRACK 6 *Net Centric Operations* Session 4A6	5585 - Testing Concept of Operations in DoD's Net Centric Environment *Mr. Steve Reeder, South Carolina Research Authority (SCRA)*	5798 - Agile Governance for SOA-Based Military Systems of Systems *Mr. Robert Beck, Villanova University*	
Palm I	TRACK 7 *System Safety* Session 4A7	5460 - The DoD's Proactive Approach to Emerging Contaminants: Managing Risks Today for Tomorrow's Warfighter and Mission Readiness *Dr. Carole LeBlanc, Office of the Deputy Under Secretary of Defense*	5439 - Safe-Escape Analysis System Safety Engineering Study *Mr. David Hall, SURVICE Engineering Company*	5377 - Risk and System Safety in Aerospace Systems Engineering *Dr. Daniel Schrage, Georgia Tech*
Palm II	TRACK 8 *Education & Training* Session 4A8	5494 - Development of Systems Engineers in the Sensors & SONAR Systems Department *Mr. Lawrence Lazar, Naval Undersea Warfare Center*	5617 - Systems Engineering and the Art of Seeing *Dr. Robert Monson, Lockheed Martin Corporation*	5792 - Understanding Social Networks—A Key Requirement for System Engineers *Mr. Karl Selke, Evidence Based Research, Inc.*

Break in the Regatta Pavilion

10:15 am - 12:00 pm — concurrent sessions

Session		
TRACK 1 *Systems Engineering Effectiveness* Session 4B1	5490 - USAF Type Certification of Commercial Derivative Aircraft *Mr. Thomas Morgan, USAF*	6135 - Global Positioning System Case Study *Mr. Randall Bullard, Air Force Center for Systems Engineering*
TRACK 2 *Systems Engineering Effectiveness* Session 4B2	5759 - Sensor Resource Allocation as a Driver in Ballistic Missile Defense System Concept Development *Mr. Ravi Moorthy, Lockheed Martin MS2*	5369 - Benchmarking Operational Configuration in a Spiral Development Process: Ballistic Missile Defense System *Mr. Hannibal Wright, Barca Strategy and Technology Consulting, LLC*
TRACK 3 *Program Management* Session 4B3	5850 - How to Talk to a Program Manager *Dr. John Mishler, Software Engineering Institute*	U.S. Department of Defense (DoD) Approach to Best Practices: Building Evidence for Practice Selection Based on Real Experiences *Dr. Forrest Shull, Fraunhofer Center Maryland*
TRACK 4 *Logistics, Supportability, and Readiness* Session 4B4	5773 - Implementing a Systems Engineering Risk Program in a Sustainment Environment *Mr. James Miller, USAF*	5826 - Risk Management and Software Life Cycle Selection *Mr. Thomas McDermott, Georgia Tech Research Institute*
TRACK 5 *Modeling & Simulation* Session 4B5	5397 - Efficacy of Modeling & Simulation in Defense Life Cycle Engineering *Mr. Donald Cox, Raytheon Missile Systems*	5355 - Modeling Integrated Logistics Systems to Support Transformation in the U.S. Coast Guard *Mr. Patrick Cumby, VectorCSP, LLC*
TRACK 6 *Net Centric Operations* Session 4B6	5820 - Reducing Acquisition Costs Through Incremental Upgrades by Migrating to SOA *Mr. Tim Greer, Lockheed Martin Corporation*	5320 - Toward an Intelligent Military Enterprise: An Introduction to an Approach to Joint Forces Based on Meta-Systems Theory *Dr. Kent Palmer, UniSA SEEC*
TRACK 7 *System Safety* Session 4B7	Overview of DoD Environment, Safety and Occupational Health Requirements, Terminology, System Safety Methodology and Risk Assessment *Mr. Sherman Forbes, USAF SAF/AQRE*	Overview of Environment, Safety and Occupational Health Activities within Systems Engineering *Mr. Sherman Forbes, USAF SAF/AQRE*

12:00 pm Lunch in the Regatta Pavilion

Thursday, October 25, 2007

concurrent sessions **1:30 pm - 3:00 pm**

Room	Track			
Bayview A	TRACK 2 *Systems Engineering Effectiveness* Session 4C2	5814 - Defense System and Large-Scale Systems Based on Terminal Control *Mr. Xiang-Wen Xiong, Zhongheng High-Tech Institute, Inc.*		
Bayview B	TRACK 4 *Logistics, Supportability, and Readiness* Session 4C4	5416 - The Deployment Readiness Service: The Challenges of Implementing a Service Oriented Architecture in a Legacy System Environment *Mr. George Dalton, USAF*		
Bayview C	TRACK 5 *Modeling & Simulation* Session 4C5	5838 - Generic Sensor Model *Dr. Stanley Hack, Lockheed Martin MS-2*	5852 - Event Timeline Analysis in Multi Mission Scenarios with System Simulation Models *Mr. Ravi Moorthy, Lockheed Martin MS2*	5428 - A Prototype Tool for Concept Design Modeling and Optimization of Combat Systems *Mr. Vikram Ganesan, General Dynamics Land Systems*

Conference Adjourns

Track Chairs

Systems Engineering Effectiveness:
- Mr. Al Brown
- Ms. Sharon Vannucci
- Mr. Bob Lyons

Logistics Supportability & Readiness:
- Mr. Chuck Silva
- Mr. Joel Moorvich

Test & Evaluation in Systems Engineering:
- Col Rich Stuckey, USAF
- Mr. Tom Wissink

Program Management:
- Mr. Hal Wilson

Modeling & Simulation:
- Mr. Jim Hollenbach
- Mr. Gary Belie

Net Centric Operations:
- Mr. Jack Zavin
- Dr. Rich Eilers
- Dr. Tom Wickstrom

Best Practices & Standardization:
- Mr. Paul Croll

Software:
- Dr. Tom Christian

Education & Training:
- Mr. George Mooney

Integrated Diognostics:
- Mr. Howard Savage
- Mr. Dennis Hecht

Additional Authors

Track	Abstract	Paper Title	Authors
1A1	5305	Are We Ready for CMMI®? If Not, Let's Fix Ourselves	Mr. Al Florence
1A2	5454	Cost As an Independent Variable and Trade Studies	Mr. Ed Casey
1A3	5404	How to Reduce Schedule Uncertainty by Integrating Sound Management Methods with Systems Engineering Best Practices	Mr. Gary Langford
1A4	5498	System Verification Organization Tutorial	Mr. Jeffrey Grady
1A6	5542	Best-In-Class Early Defect Detection and Defect Prevention	Mr. Timothy Olson
1A7	5784	Operational Concepts: Using Cases & Scenarios to Understand User's Needs	Mr. Raymond Jorgensen
1A8	5577	Introduction to SysML & Object Oriented Systems Engineering Methodology (OOSEM)	Mr. Abe Meilich
1C1	5307	Requirements Development and Management	Mr. Al Florence
1C2	5326	Integrating Systems Engineering with Earned Value Management	Mr. Paul Solomon
1C4	5511	Modeling Sustainment and Risk Mitigation for Net-Enabled Realities	Mr. Philip Boxer Ms. Lisa Brownsword Mr. Bill Anderson Mr. Jim Smith
1C5	5540	Introduction to Reliability Analysis	Dr. Meng-Lai Yin
1C6	5544	How to Define Practical Systems Engineering Metrics	Mr. Timothy Olson
1C7	5582	Leading Effective System of Systems (SoS) Technical Reviews	Mr. David Walden
2C1	5378	DoD's Systems Engineering Revitalization Efforts—An Update	Mr. Robert Skalamera Col Richard Hoeferkamp
2C1	5399	The Effectiveness of Systems Engineering: On Federal (DoD) System Development Programs	Mr. Al Mink Mr. Dennis Goldenson Mr. Geoff Draper Mr. Al Brown Mr. Ken Ptack
2C2	5402	A Test Strategy Done Early Drives Test Planning and Successful Testing	Mr. William Lyders
2C2	5503	A Vector Check - Revitalizing DT&E	Mr. Chris DiPetto
2C3	5531	The Joint Partnership Between Program Management and Systems Engineering	Mr. Samuel Son
2C4	5508	Integrated Structural Health Monitoring System Using Lamb Waves	Maj Joerg Walter, USAF Dr. Som Soni
2C4	5797	Environment, Safety, and Occupational Health (ESOH) - Design Considerations to Support Sustainability and Readiness	Ms. Patricia Huheey Ms. Karen Gill
2C5	5421	M&S-Related Guidelines for Contracting	Mr. Michael Truelove
2C5	5446	Implementing the Acquisition M&S Master Plan	Mr. Michael Truelove Mr. Jim Hollenbach
2C5	5606	M&S Planning and Employment Best Practices	Mr. Jim Hollenbach
2C6	5430	The Use of Enterprise Architecture to Support the Development of the Next Generation Air Transportation System (NextGen)	Mr. Jerry Friedman Mr. David Snyder
2C6	5500	Complex Systems of Systems: The Dual Challenge	Mr. Philip Boxer Ms. Lisa Brownsword Mr. Ed Morris
2C7	5491	Systems Engineering Process Improvements at NAVAIR	Mr. Michael Gaydar
2C7	5780	Simplifying & Scaling Engineering Processes: Unifying Business Units and Engineering Disciplines	Mr. Raymond Jorgensen
2D1	5405	Systems Engineering Realization for the Future	Ms. Karen Bausman
2D1	5484	Tools and Resources to Enable Systems Engineering Improvement	Mr. Michael Kutch, Jr. Mr. Michael Knox

2D1	5626	Good Systems Engineering Insures Good Producibility	Dr. Thomas Christian, Jr. Mr. Rich Stepler Mr. Hamid Akhbar
2D2	5489	Applying Design of Experiments Methodology to Sortie Generation Rate Evaluation	Mr. Joseph Tribble Mr. Matthew Rodakis
2D2	5774	Implementing and Measuring Test Program in a Sustainment Environment	Mr. James Miller
2D3	5365	PValue of Systems Engineering: Analysis & Results from Previous and Current Studies of Over 100 System Development Projects	Mr. Allan Mink, II
2D3	5435	Reforming the DoD Acquisition Process - A Systems Engineering Approach	Mr. Stephen Ward Mr. Christopher Perkins
2D3	5779	Applying Systems Engineering During Pre-Acquisition Activities	Lt Col Mark Wilson, USAF Mr. Jeff Loren
2D4	5271	Leveraging EMS for Condition Based Maintenance	Mr. Thomas Hawley
2D4	5287	Sparing Satellites--Comparitive Strategies of In-Orbit & In-Factory Storage	Mr. James Mazzei Mr James Ayers Ms. Camille Keeley Mr. Jon Westergaard
2D4	5368	Real-Time Diagnostics for High Availability Systems	Mr. Edward Beck
2D5	5427	Modeling and Simulation Resource Reuse Business Model	Mr. Dennis Shea Dr. John Hampson
2D5	5603	Modeling and Simulation Support Plan	Mr. David Henry
2D5	6099	Modeling and Simulation Education for the Acquisition Workforce: Requirements Analysis	Mr. David Olwell Ms. Jean Johnson
2D6	5576	Systems Engineering in the Cognitive and Social Domains of Net Centric Operations	Dr. Abe Meilich
2D6		Global Information Grid (GIG), Technical Foundation (GTF) and GIG Compliance Assessment (GICA)	Mr. Brendan Goode
2D6		Global Information Grid (GIG) Performance Assessment Framework	Mr. Tony Modelfino
2D7	5781	Integrating Engineering Project Management and Product Development Processes	Mr. Raymond Jorgensen
2D7	5831	Engineering for System Assurance – Legacy, Life Cycle, Leadership	Mr. Paul Croll
2D8	5315	Requirements for a Chief Software Engineering in a DoD Acquisition Agency	Mr. Al Florence
2D8	5481	Developing An Integrated Process Methodology For Interim Software Releases	Mr. Tim Woods Mr. Jerrell Stracener
3A1	5536	A Day in the Life of a Verification Requirement	Mr. Stephen Scukanec Mr. James van Gaasbeek
3A1	5806	Investigating the Use of SysML on the FBX-T Radar Program	Mr. Chad Schuyler Mr. Mark Minnucci Ms. Caroline Elias
3A1	5824	Change Management of UML-Based Systems Engineering Artefacts	Mr. David Price
3A2	5520	System Test and Evaluation in the DARPA Immune Building Demonstration Program	Mr. Mark Saxon Mr. James Risser
3A2	5553	Modeling and Simulation in the Navy Warfare Systems Test & Evaluation Enterprise	Ms. Shala Malone Mr. Richard Reading
3A3	5523	Systems Engineering Plan Preparation Guide Update	Mr. Chester Bracuto
3A3	5525	Toward a Unified Systems Engineering Plan	Mr. Robert Scheurer
3A3	5587	Integrating Risk & Knowledge Management	Mr. David Lengyel
3A4	5546	Defining Lean Service and Maintenance Processes	Mr. Timothy Olson
3A5	5538	Advancing the FEDEP for Simulation Based Acquisition	Dr. Katherine Morse Mr. Paul Lowe
3A5	5614	Live Virtual Constructive (LVC) Architecture Interoperability Assessment	Mr. Warren Bizub Mr. Ken Goad

3A6	5497	Achieving Agility in Cyberspace	Mr. Philip Boxer Mr. Edwin Morris
3A6	5815	Distributed Firewalls	Mr. Alejandro Gastelum
3A7	5592	CMMI—Next Steps	Ms. Kristen Baldwin Mr. Lawrence Osiecki Dr. Karen Richter
3A7	5743	CMMI Instructional Challenges to Systems Engineers in Small Settings	Dr. Mary Anne Herndon
3A8	5526	Defining Software Component Specifications: An Open Approach	Mr. Kenneth Klein
3A8	5676	System Engineering and Software Exception Handling (SEH)	Mr. Herbert Hecht
3B1	5557	How to Measurably Improve Your Requirements	Mr. Timothy Olson
3B1	5670	Review of the Roles of a System Architect	Mr. Tomasz Lomecki Dr. Dinesh Verma Mr. Eirik Hole
3B1	5865	Case Studies: A Common Language Between Engineers and Managers	Capt DeWitt Latimer IV, USAF
3B2	5473	Joint Mission Environment Test Capability (JMETC)	Mr. Richard Lockhart
3B2	5585	Testing Concept of Operations in DoD's Net Centric Environment	Mr. John Eleazer Mr. Charles Reeder
3B3	5381	Systems Engineering and Program Management – How Different are They?	Ms. Lori Zipes
3B3	5799	Systems Engineering Analysis to Improve Concept Development of Complex Defense Systems	Mr. Michael Harper Mr. Philip Butler Dr. Jerrell Stracener
3B4	5530	Considerations & Propose Approach for Integrating New Hardware and Software into the Legacy Military Aircraft Avionics Systems – a Systems Engineering Lesson-Learned Perspective on the C-17 Program	Mr. Phat Vu
3B4	5903	Asset-Based PBL for Navy Warships – A Case Study for LCS Class Ship	Mr. Michael Mahon
3B4	5954	Integrated Diagnostics Closed Loop Data System (At the Point of Use) (Support Systems Knowledge Engineering Enhances Traditional Support Equipment Systems Engineering)	Mr. Steven Head Mr. John Bauer
3B5	5426	A Methodology for Assessing and Prioritizing the Risks Associated with the Level of Verification, Validation and Accreditation (VV&A) of Models and Simulations	Dr. James Elele
3B5	5431	Standardized Documentation for Verification, Validation, and Accreditation - A Status Report to the Systems Engineering Community	Mr. Kevin Charlow Mr. Curtis Blais Mr. David Broyles Ms. Marcy Stutzman
3B6	5386	Application of Autonomic Agents for Global Information Grid	Mr. David Cox Mr. Youssif Al-Nashif Dr. Salim Hariri
3B6	5847	Architecture-Based Concept Evaluation in Support of JCIDS	Dr. David Jacques Dr. John Colombi
3B7	5485	Executing a Successful CMMI Maturity Level 3 SCAMPI For SPAWAR Systems Center Charleston	Mr. Michael Kutch Ms. Sandra Guidry
3B7	5808	FISMA Operational Controls and Their Relationship to Process Maturity	Mr. Ronda Henning
3B8	5764	A Convergence of Technologies for Better Software NOW!	Mr. Dorothy Acton
3B8	5803	Identifying Acquisition Patterns of Failure Using System Archetypes	Mr. William Novak Dr. Linda Levine
3B8	5883	Acoustic Rapid COTS Insertion (ARCI) Advanced Processor Build (APB) Systems	Mr. Gary Tissandier
3C1	5594	Handbook on Engineering for System Assurance	Ms. Kristen Baldwin Ms. Christine Hines
3C1	5805	A Pragmatic Approach for Defining and Utilizing System States and Modes	Mr. Mark Minnucci Mr. Chad Schuyler Ms. Caroline Elias

3C2	5380	Applications of Systems Engineering to Pre-Milestone A Projects	Ms. Lori Zipes
3C2	5464	"Do it right, do it early; Do it early, Do it right" -- Considerations for the Early Stages of Concept, System, and Systems-of-Systems Definition	Mr. Jeff Loren Lt Col Mark Wilson
3C3	5450	Airborne Signals Intelligence Payload (ASIP) Program Integrated Risk Management	Mr. Daniel Bolek
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3C6	5848	System of Systems Implications for Operational Test	Dr. John Colombi Dr. David Jacques
3C7	5760	How to Paint a Room: The Role of Specs & Standards in SE	Mr. Robert Kuhnen
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3D1	5505	Discussion of the U.S. Army RDECOM APS Objective Trade Study	Mr. Frank Salvatore
3D2	5593	Systems Engineering in a Systems of Systems Environment - Defense Update	Ms. Kristen Baldwin Dr. Judith Dahmann Mr. Ralph Lowry
3D2	5602	ASW System-of-Systems Engineering Analysis Applied in an LCS ASW Integration Pilot Project	Mr. G. Richard Thompson
3D2	5832	A Brigade Capability Approach to the Evolution of Current Ground Combat Systems	Ms. Roberta Desmond Mr. Kenneth Mick Mr. Rick Burtnett
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3D5	5409	Information Modeling for Systems Integration	Ms. Claudia Rose Mr. Al Brenner Ms. Kim Idol
3D5	5575	Simulation Supported Decision Making	Mr. Gene Allen

3D5	5835	Unifying Systems Engineering Simulations	Mr. Kevin Tang Mr. Glenn Beach Mr. Rakesh Patel Mr. Jason Ueda
3D6	5407	Quantitative Comparison of Alternative Designs for JC3M System	Mr. Gregory Miller Mr. Ian Finn
3D6	5445	Advanced Net Centric Simulation for Aerospace Command and Control	Ms. Kimberly Kendall
3D7		Anatomy of an Award Winning Safety Program: A Case Study of the SSGN OHIO Class Conversion Safety Program	Mr. Ricky Milnarik Mr. Bryan Stanley Mr. Thomas Cook Mr. Norman Gauthier
3D7		Addressing Environment, Safety and Occupational Health Issues for the Mine Resistant Ambush Protected (MRAP) Vehicle Program	Ms. Jennifer Malone
3D7			Mr. Mike Demmick
3D8	5438	Autopsy of A Good Systems Engineer – An Endangered Species	Mr. Jimmy Thai
3D8	5522	Systemic Root Cause Analysis of Acquisition Program Issues	Mr. Dave Castellano Ms. Laura Dwinnell
3D8	5873	Reference Curriculum for a Graduate Program in Systems Engineering	Dr. Rashmi Jain Dr. Dinesh Verma Mrs. Anithashree Chandrasekara
4A1	5499	A Robust Process for Resolving Interface Design Issues in the Complex Concurrent LCS System Engineering Environment	Mr. William Traganza Mr. Joseph Conway Mr. Joseph Darwood
4A1	5785	UAI Part 1: Increasing Flexibility Through Data Driven Interfaces; Part 2: Describing Flexibility as an Operational Capability	Mr. Jonathan Miller Mr. Oren Edwards
4A2	5443	Technology Readiness Assessments; Milestone B Certification Requirement for Technologies To Be Demonstrated in a Relevant Environment	Dr. Jay Mandelbaum
4A2	5453	Meeting Enterprise System Engineering Challenges for the U.S. Next Generation Air Transportation System (NextGen)	Ms. Catherine Bolczak Mr. Robert Humbertson Mr. John Mack Mr. Gerald Friedman
4A2	5675	Implementing the Technology Maturity Vector	Mr. Joseph Terlizzese, Jr.
4A3	5532	Systems Engineering Approach to Prioritize Projects	Mr. Thomas Condron Maj Christopher Lardner
4A3	5849	Managing Requirements to Manage Scope in the Case of MUOS	Ms. Christy Howard Ms. Debra Shannon CDR Ralph (Trip) Braund
4A3	5867	Organizational Leadership and Management Dynamics for Technical Execution in Acquisition Programs	Mr. Francis Sisti Captain DeWitt Latimer, IV
4A4	5419	DoD/OSD Sustainment/Readiness Initiatives: Reduction of Total Ownership Costs (R-TOC) and Value Engineering (VE)	Dr. Danny Reed Mr. David Erickson
4A4	5493	Innovation Strategies for Affordable Readiness	Mr. Tom Choinski
4A4	5629	Relating Investment In Reliability Engineering To Reliability Improvement And Reduction Of Total Ownership Cost	Dr. James Forbes Mr. E. Andrew Long
4A5	5444	Aircraft Flight Simulator Acceptance Criteria	Mr. Dean Carico
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4A6	5798	Agile Governance for SOA-Based Military Systems of Systems	Dr. Robert Beck Ms. Jessica Byrnes Ms. Elliot Sloane Ms. Sue Metzger
4A7	5377	Risk and System Safety in Aerospace Systems Engineering	Dr. Daniel Schrage

4A7	5439	Safe-Escape Analysis System Safety Engineering Study	Ms. David Hall Mr. Kenneth Chirkis
4A7	5460	The DoD's Proactive Approach to Emerging Contaminants: Managing Risks Today for Tomorrow's Warfighter and Mission Readiness	Dr. Carole LeBlanc
4A8	5494	Development of Systems Engineers in the Sensors & SONAR Systems Department	Mr. Lawrence Lazar
4A8	5617	Systems Engineering and the Art of Seeing	Dr. Robert Monson
4A8	5792	Understanding Social Networks- A Key Requirement for System Engineers	Mr. Karl Selke
4B1	5490	USAF Type Certification of Commercial Derivative Aircraft	Mr. Thomas Morgan Mr. Joel Ligon
4B1	6135	Global Positioning System Case Study	Mr. Randall Bullard
4B2	5369	Benchmarking Operational Configuration in a Spiral Development Process: Ballistic Missile Defense System	Mr. Hannibal Wright
4B2	5759	Sensor Resource Allocation as a Driver in Ballistic Missile Defense System Concept Development	Mr. Ravi Moorthy Mr. Jay Davidson Mr. Mark Russel
4B3	5850	How to Talk to a Program Manager	Ms. Anita Carleton Dr. William Nichols Dr. John Mishler
4B4	5773	Implementing a Systems Engineering Risk Program in a Sustainment Environment	Mr. James Miller
4B4	5826	Risk Management and Software Life Cycle Selection	Mr. Thomas McDermott
4B5	5355	Modeling Integrated Logistics Systems to Support Transformation in the U.S. Coast Guard	Mr. Patrick Cumby
4B5	5397	Efficacy of Modeling & Simulation in Defense Life Cycle Engineering	Mr. Donald Cox Dr. Salim Hariri
4B6	5320	Toward an Intelligent Military Enterprise: An Introduction to an Approach to Joint Forces Based on Meta-Systems Theory	Dr. Kent Palmer
4B6	5820	Reducing Acquisition Costs Through Incremental Upgrades by Migrating to SOA	Mr. Tim Greer
4B7		Overview of DoD Environment, Safety and Occupational Health Requirements, Terminology, System Safety Methodology and Risk Assessment	Mr. Sherman Forbes
4B7		Overview of Environment, Safety and Occupational Health Activities Within Systems Engineering	Mr. Sherman Forbes
4C2	5814	Defense System and Large-Scale Systems Based on Terminal Control	Mr. Xiang-Wen Xiong
4C4	5416	The Deployment Readiness Service: A Case Study of the Challenges of Implementing a Service Oriented Architecture in a Legacy System Environment	Mr. George Dalton, II Dr. Robert Mills
4C5	5428	A Prototype Tool for Concept Design Modeling and Optimization of Combat Systems	Mr. Vikram Ganesan Mr. Philip Morgan
4C5	5838	Generic Sensor Model	Dr. Stanley Hack Dr. Josef Keith
4C5	5852	Event Time Line Analysis in Multi Mission Scenarios with System Simulation Models	Mr. Ravi Moorthy Mr. Paolo Trinchieri Mr. Todd Brown

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Notes

Sparing Satellites
Comparative Strategies of On-Orbit and In-Factory Storage

10^{th} Annual Systems Engineering Conference

by

James Mazzei, Camille Keeley, Jon Westergaard, James Ayers & Helen Wong

Outline

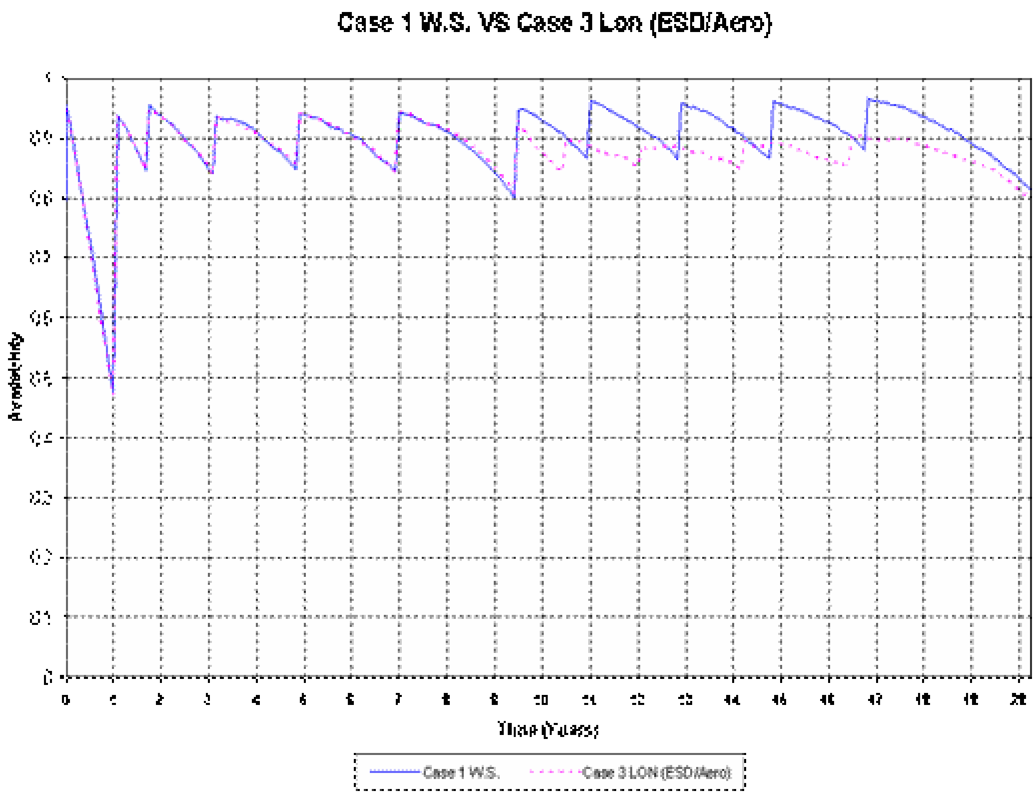
- Introduction
- Warm Spare vs. Launch on Need Comparison
- Analysis of Operational Programs
  - Defense Satellite Communications System
  - Tactical Data Relay Satellite System
  - Geostationary Operational Environmental Satellite
- Commercial Systems
- Advantages & Disadvantages of OOS
- Conclusion

Introduction

- Time required to produce satellite
- Generalized Availability Program (GAP)
- Milestone Schedule Elements

Warm Spare vs. Launch on Need

Case 1 vs Case 3 LON (ESD/Aero)



THE AEROSPACE CORPORATION

Analysis of Operational Programs

- A military satellite communications system
  - 240 day LON = $1M recurring
  - 60 day LON = $22.5 M non-recurring & $5.3 M recurring
- Tactical Data Relay Satellite System
  - On-orbit savings = $6.5 M over 2 years

Commercial Systems

Commercial systems universally store on orbit to take advantage of surge requirements and difficult maintenance issues.

Advantages & Disadvantages of On-Orbit Storage

- Advantages: Cost (with assumptions).

- Satellites do not fail in order of launch
  - UHF Follow-On failures on orbit
    - Flight 3 and Flight 7
  - UHF Follow-On operational spacecraft
    - Flight 2 and Flight 4 (among others)

Advantages & Disadvantages of On-Orbit Storage

- Advantages: Cost (with assumptions).
- Disadvantages:
  - Fuel budget
  - TT&C components extended life requirement
  - Additional radiation
  - Thermal/power degradation
  - Additional ground station resources required

Conclusion

Cost savings wins (with assumptions).

10^{th} Annual
NDIA Systems Engineering Conference

October 22-25, 2007
San Diego, CA

Requirements for a Chief Software Engineer in a DoD Acquisition Agency

Al Florence
The MITRE Corporation

Presented At

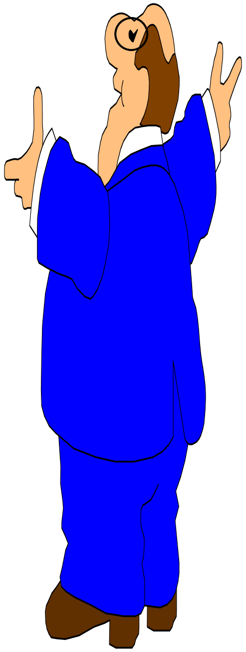
- Air Weapons Integration Seminar, Institute for Defense and Government Advancement (IDGA); Silver Spring, MD; 2006
- System and Software Technology Conference (SSTC), Poster session; Salt Lake City; 2005
- Acquisition of Software-Intensive Systems Conference; Washington DC; 2004

Agenda

- Introduction
- Qualification Areas

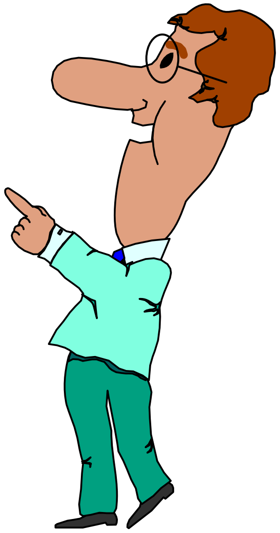
Education	Configuration Management
Years Experience	Risk Management
Project Management	Metrics
Proposals	Life Cycle
Planning	Systems Engineering
Requirements	Acquisition
Design	Standards
Implementation	Process Improvement
Test	Writing Skills
Quality Assurance	Communication Skills

- Interviewing
- Candidate Evaluation
- Summary
- Contact Information



Introduction

- A large weapons systems project had a need for a Chief Software Engineer at the program office to oversee and manage the software development effort of several contractors.
- The project was incrementally being developed with current increment in the design phase while a request for proposal was being developed for the next increment.
- The applications have critical real-time embedded command, control, and communications software with many interfaces to other DoD systems.
- The agency asked this author to construct a list of the required experience and skills that this Chief Engineer should have and to support the selection.



Introduction (concluded)

- This position is critical to the success of the weapons systems' mission.
- Software is key in this success; if software does not work, the mission fails.
- Software is an area that traditionally has not received the attention that it deserves.
- In order for software to meet mission requirements it needs to be of high quality and maintainable, developed within cost and schedule, and managed at the highest professional and technical levels.
- The Project Office Software Chief Engineer responsible for this has to have the appropriate education, experience and skills at the highest possible levels.
- The contents of this presentation can be used:
  - In other organizations looking to hire a Chief Software Engineer.
  - To increase skills of Software Engineers in the Project Office through training.

Where are We?

- Introduction
- Qualification Areas

Education	Configuration Management
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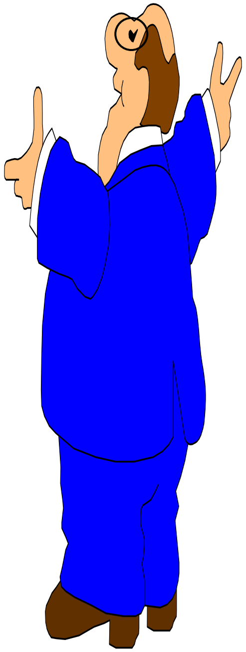

Qualification Areas

- This position requires expertise in multiple areas of software development, including technical, acquisition, and management throughout the entire life cycle.
- It is recognized that it would be difficult to find the ideal candidate.
  - A selection methodology is included to guide the selection of the best possible candidate.
  - Gaps in the qualification areas can be augmented with other individuals in the program office.
- The following foils present these qualification areas and describes their appropriate attributes for this position.
- In all cases, the experience is relative to software-intensive systems, preferably embedded and real-time weapon systems.

Education
(Qualification Area)

- A degree in a technical discipline (engineering, computer science) is critical. An advanced degree (MS or Ph.D) is advantageous.
- Additional training in related fields is a benefit (such as acquisition, networks, radar, etc.).
- Training in specific domain-applicable technologies is also a benefit.
- Education should be viewed with and tempered with the experience related to the listed qualification areas.

Years Experience
(Qualification Area)

- Experience in large software intensive development efforts especially for:
  - Real-time, embedded, critical weapons systems with many interfacing subsystems with multiple contractors.
- Experience in the listed qualification areas is also viewed as important.

Management
(Qualification Area)

- Experience in project management for a software intensive system, preferably across the full life cycle.
- Project management, program management, software management, and supervision should be considered.

Proposal Development / Evaluation
(Qualification Area)

- Experience in developing proposals from the contractor side.
- Experience in writing Requests for Proposal (RFP) and Statements-of Work (SOW).
- Experience in evaluating proposals and performing source selection.

Planning
(Qualification Area)

- Experience in planning life cycle activities, budgets, schedules, and resources for software intensive development efforts from both a development and acquisition point-of-view.
- Planning should include developing and evaluating plans for conducting the activities related to the listed qualification areas.

Requirements
(Qualification Area)

- Knowledge of the nature and role of requirements in software intensive systems.
- Experience in gathering user needs, translating them into technical and programmatic requirements, specifying, verifying, validating and allocating them to lower levels of abstraction.
- Experience in management of the requirements throughout their entire life cycle.

Design
(Qualification Area)

- Knowledge of software design techniques and tools.
- Experience in the design of software intensive systems from:
  - conceptual design,
  - to high level architecture,
  - to preliminary design,
  - to detailed design.
- Ability to review contractor proposed and developed design architectures.

Implementation
(Qualification Area)

- Knowledge of key programming languages (applicable to the domain in question).
- Experience in:
  - coding software solutions,
  - debugging,
  - integrating software modules.
- Ability to review contractors' implemented code.

Test
(Qualification Area)

- Knowledge of software testing techniques and tools.
- Experience in the formal and informal testing of software intensive systems, ranging from:
  - unit testing,
  - integration testing,
  - formal qualification testing (FQT),
  - system integration tests,
  - system acceptance tests,
  - certification tests.
- Experience in the development of test plans, test descriptions, and test reports, and the execution of the tests.

Quality Assurance
(Qualification Area)

- Knowledge of software quality assurance activities, tools, and techniques.
- Experience in establishing and conducting quality assurance activities for large software programs, with a focus on ensuring that the:
  - processes,
  - procedures,
  - standards

  that are used on the project are followed as defined.

Configuration Management
(Qualification Area)

- Experience in establishing and conducting configuration management activities for large software programs.
- Experience in baselining requirements and managing changes to them.
- Experience in conducting impact assessments of proposes changes
- Experience in serving on configuration control boards.

Risk Management
(Qualification Area)

- Knowledge of risk management concepts.
- Experience in establishing and conducting risk management activities for software intensive programs, including:
  - the identification of project risks,
  - prioritizing them,
  - development and execution of mitigation plans and alternatives (contingencies).

Metrics
(Qualification Area)

- Knowledge of metrics definition and application.
- Experience in the:
  - establishing metrics goals,
  - collection of measurements on activities and products,
  - definition and creation of metrics,
  - analysis of resulting metrics,
  - actions taken based on the analysis,
  - reporting of resulting findings.

Life Cycle Paradigms
(Qualification Area)

- Knowledge of life cycle models for software development, including incremental, evolutionary, and spiral.
- Experience in defining and managing a software intensive system all the way through its life cycle, from operational concept through specification, deployment and retirement.
- Experience in defining and executing entry and exit criterion for life cycle reviews and milestones

System Engineering
(Qualification Area)

- Knowledge of systems engineering practices and processes for software intensive systems.
- Experience in defining and applying a software engineering process within a systems engineering process.

Acquisition
(Qualification Area)

- Experience in the acquisition of software intensive systems.
- Application of the listed qualification areas from an acquisition perspective.
- Sponsor of specific acquisition processes.
- The ability to influence others in the importance and proper application of these qualification areas, both at the contractor and program office level, are of extreme importance.

Standards
(Qualification Area)

- Knowledge of and experience in the selection and application of commercial and DoD standards to complex software-intensive systems.
- Knowledge of the role of standards in the specification, design and development of large software-intensive systems.
- Knowledge of sponsor specific standards for architecture, development, management.

Process Improvement
(Qualification Area)

- Knowledge of the Software Engineering Institute's (SEI) Capability Maturity Model Integration CMMI®.
- Experience in measurement of process effectiveness.
- Experience in improvement of process and procedures that are followed during:
  - acquisition,
  - development,
  - operation

  of software intensive systems.

® CMM is a registered trademark of the SEI

Writing Skills
(Qualification Area)

- The ability to write both technical and programmatic:
  - reports,
  - briefings,
  - documents,
  - plans,
  - white papers, etc.

  in a clear, understandable and concise fashion.

Communication Skills
(Qualification Area)

- The ability to communicate with management and technical individuals in a clear, understandable and concise fashion.
- The ability to act as a negotiator between the contractor and acquisition organization.

Where are We?

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- Qualification Areas

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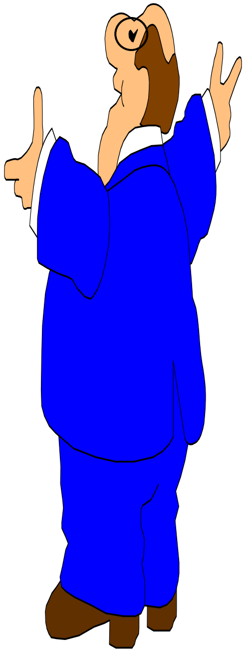

Interviewing

- Prior to starting the interview the nature of the project and the position should be explained to the candidate.
- The organization and project should be explained in a fashion that entices the candidate to want to accept an offer.
- The importance of the position to the success of the mission should be emphasized.
- For each area the following questions should be asked as a minimum:
  - Would you please describe your experience related to (qualification area)
    - How much of this experience is on a contractor development effort?
    - How much of this experience is on an acquisition effort?
- Answers to these and other questions may influence what additional questions need to be asked for that area or other areas.

Interviewing (concluded)

- If the candidate does not provide the needed information, additional questions can be asked in an attempt to elicit the information.
- Interview notes should include personal style; is the candidate:
  - arrogant or personable, poised or rattled?
  - these are subjective impressions that can still be important to the interpersonal aspects of his/her job.
- Additionally, one may ask the candidate to provide samples of work/papers written.
- All candidates should be ranked against each other in relation to each qualification area.
- At least two interviewers should interview each candidate to arrive at objective evaluations.
- The following foils present a methodology (an example) to guide in the selection of the best possible candidate.

Where are We?

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Example - Candidate Evaluation

		Candidate 1		Candidate 2		Candidate 3		Candidate 4	
Qualification Area	Weight	Rank	Score	Rank	Score	Rank	Score	Rank	Score
Education	6	5	30	6	36	2	12	8	48
Years Experience	7	6	42	9	63	7	49	6	42
Project Management	8	8	64	6	48	5	40	8	64
Proposals	7	4	28	6	42	5	35	7	49
Planning	8	3	24	6	48	7	56	4	32
Requirements	9	6	54	9	81	6	54	7	63
Design	5	6	30	8	40	5	25	9	45
Implementation	4	8	32	7	28	6	24	5	20
Test	7	6	42	8	56	5	35	4	28
Quality Assurance	6	7	42	6	36	8	48	6	36
Configuration Management	6	4	24	8	48	9	54	7	42
Risk Management	8	5	40	6	48	4	32	7	56
Metrics	6	6	36	7	42	7	42	9	54
Life Cycle	7	5	35	7	49	5	35	7	49
Systems Engineering	8	6	48	3	24	7	56	5	40
Acquisition	10	7	70	5	50	9	90	5	50
Standards	7	4	28	6	42	9	63	7	49
Process Improvement	9	6	54	5	45	7	63	8	72
Writing Skills	7	5	35	7	49	8	56	9	63
Communication Skills	8	6	48	6	48	7	56	7	56
Total Score			806		923		925		958

Candidate Evaluation (continued)

- The weight of each qualification area indicates the importance of a particular qualification area in relation to all other qualification areas and depends on the needs of the organization.
  - Weights need to be agreed on by at least two individuals to be objective (could be management of the interviewers).
- Each individual is ranked against each other on all qualification areas.
- The rank of each individual is determined by at least two interviewers to be objective.
- The score is the product of the weight and the rank.
- The total score is the sum of all scores.

Candidate Evaluation (concluded)

- The best candidate should not automatically receive a 10, experience and skills against the area should be the major consideration.
- The total score is the sum of all area scores which are the product of area weight and candidates rank for that area.
- The maximum total score is 1430.
- Any candidate receiving less than 50%, 715, should not be considered.
- If no candidates receive at least 50%, a new round of interviews should be conducted.
- When scores are close, a judgement call may be necessary.
- Interview notes on personal style and samples of work can be used to eliminate candidates or to select from among those with close high scores.

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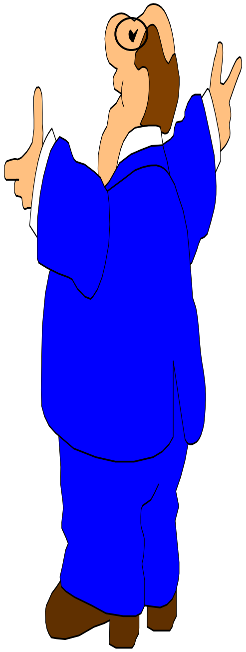
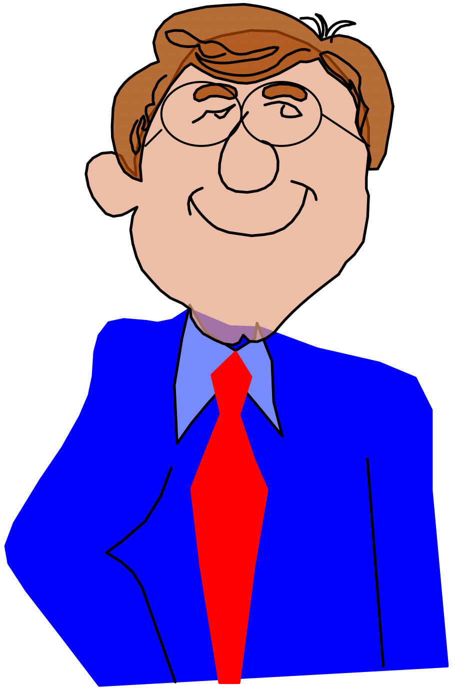


Summary

- A large complex weapons systems acquisition effort should have an experienced software chief engineer to support the effort; the experience should span the spectrum of:
  - Program/Project Management
  - Software Engineering
  - System Engineering
  - Test Engineering
  - Quality Assurance
  - Configuration Management
  - Risk Analysis
  - Metric Analysis
  - Life Cycle Activities
  - Process Engineering
- This experience should cover both supplier development efforts and acquirer acquisition efforts.
- The criterion was successfully used to select a Chief Software Engineer.

Contact Information



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The Effectiveness of Systems Engineering:

On Federal System Development Programs

First Public Release

Of Major New NDIA Study by
The Systems Engineering Effectiveness Committee
(SEEC)

Al Mink
SEEC Member
& SRA International
October 2007

SE Effectiveness
Overview

The SE Effectiveness Survey

Quantifies the relationship between the application of <u>Systems Engineering</u> best practices and the <u>performance</u> of system development projects

Projects with better Systems Engineering capabilities deliver better Project Performance!

TODAY'S OUTLINE

1. **The Challenge**
2. **The Rigor**
3. **The Results!**
4. **Conclusions & Caveats**

The Challenge
Stakeholder Analysis

Those interested in such a study – and their interests

Customers

- DoD #1 SE Issue – “Inconsistent SE Practices across life cycle”
- Validate initiatives to revitalize SE
- Increase emphasis of SE content in RFPs and Proposals

Industry (System Developers & Integrators)

- Proposal may skimp on SE; Budget pressures on SE

Associations & Academia

- Unable to fully satisfy their members and students

SE professionals

- Lack rigorous justification for their recommendations

The Challenge

Previous Studies – Partial Insights

Gruhl, National Avionics and Space Administration (NASA), 1992

Compared upfront expenditures to eventual cost growth

Herbsleb, Software Engineering Institute (SEI), 1994

Studied ROI on process improvement in software

Honour, International Council on Systems Engineering (INCOSE), 2002

Surveyed industry to compare SE Effort to cost & schedule

Valerdi & Boehm, Constructive System Engineering Cost Model (COSYSMO), 2004

Developed parametric estimation model similar to COCOMO

Boehm & Valerdi, SE ROI (COCOMO), 2006

Analyzed SE activities from COCOMO II

Others…

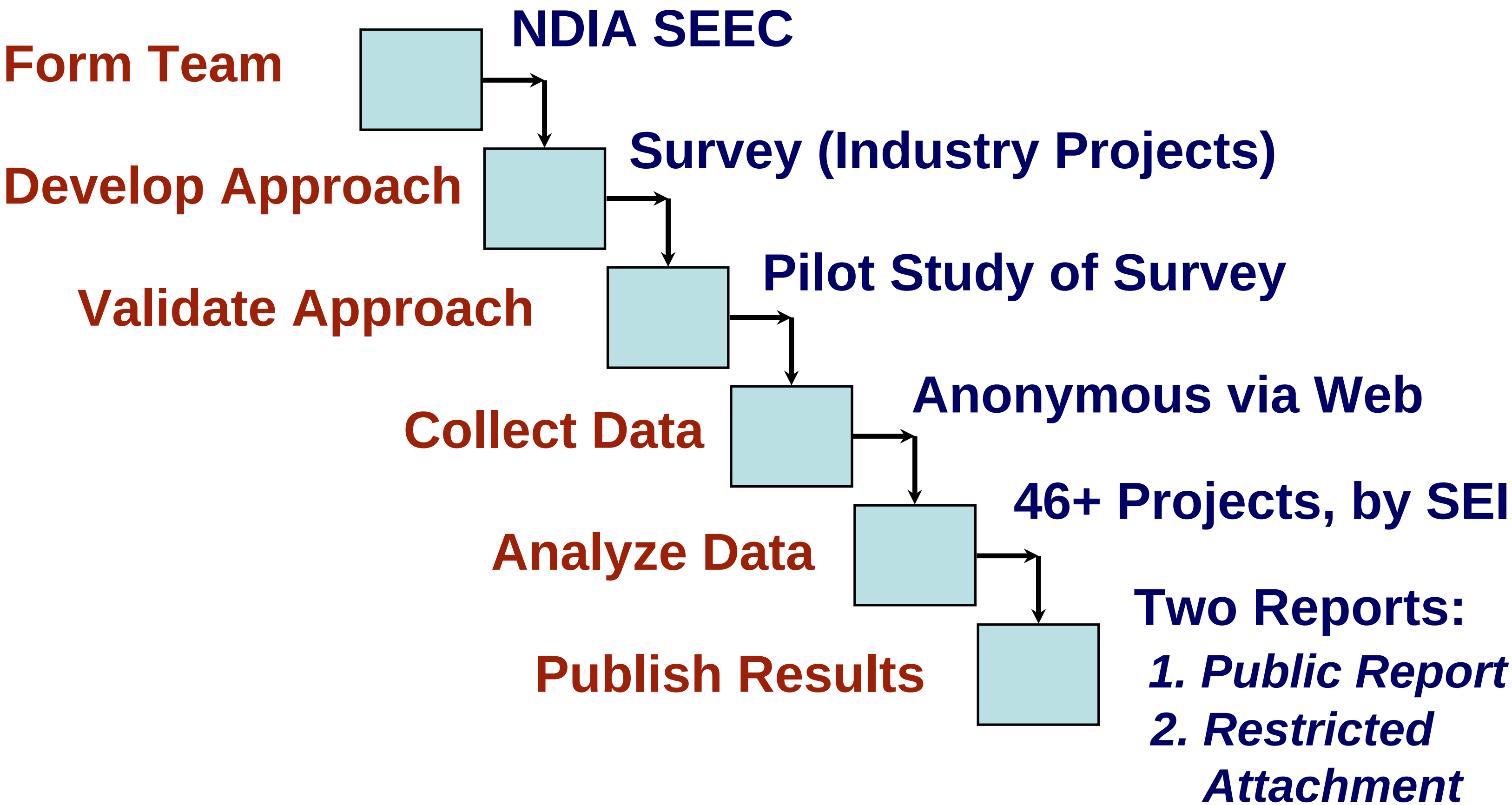
The Challenge

Previous Studies – Summary

STUDY		APPLICABILITY		
Author & Background	**Findings**	**SE Activities**	**Definition of Success**	**Characteristics of Project**
Gruhl (1992) 32 NASA Pgms	8-15% Upfront Best	First two of five development phases	Cost (Less cost overrun)	Large; Complex; all NASA
Herbsleb (1994) 13 CMM Companies	Process Improvement ROI 4.0 – 8.8	CMM Process Areas	Cost (Cost reduction through SE investment)	Various; federal contracting
Honour (2004) Survey INCOSE SEs	15-20% of project should be SE	Overall SE level of effort (Cost) & related SE quality	Cost & Schedule	Various sizes (measured by total project cost)
Boehm & Valerdi (2006) COCOMO II	SE importance grows with project size	COCOMO II RESL (Architecture and Risk)	Cost	Various sizes, but software systems only
Boehm & Valerdi (2004) COSYSMO	Estimate within 30% effort 50% - 70% of time	33 activities defined by EIA 632	Cost	Mostly successful projects from federal contractors
Ancona & Caldwell (1990) Boundary Management	Managing team boundary 15%; more is better	Team boundary activities – interface between team and external	Product Performance (Successfully marketed products)	Technology products
Frantz (1995) Boeing side-by-side projects	More SE yielded better quality & shorter duration	Defined by Frantz	Product Performance & Schedule (Quality of product and duration of project)	Three similar systems for manipulating airframes during assembly

Mink, 2007

The Rigor
Followed Planned Lifecycle



This study spanned three years

The Rigor

Formally Selected Set of SE Activities

CMMI-SW/SE v1.1

- 25 Process Areas
- 179 Goals
- 614 Practices
- 476 Work Products

Systems Engineering-related Filter

- 14 Process Areas
- 31 Goals
- 87 Practices
- 199 Work Products

Size Constraint Filter

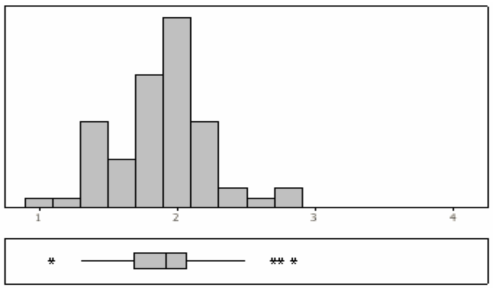
- 13 Process Areas
- 23 Goals
- 45 Practices
- 71 Work Products

Considered significant to Systems Engineering

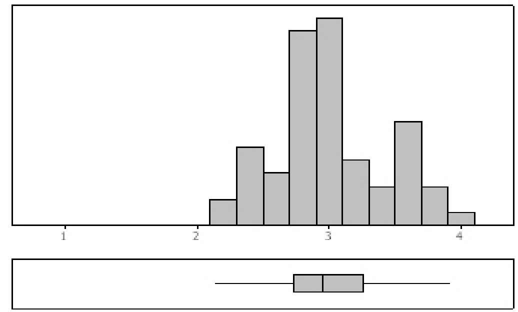
Survey was developed based on standards and recognized SE experts

The Rigor

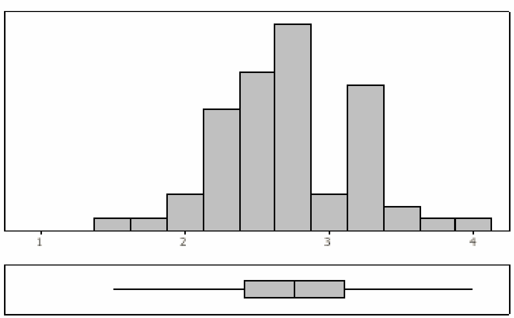
Validated Survey Responses



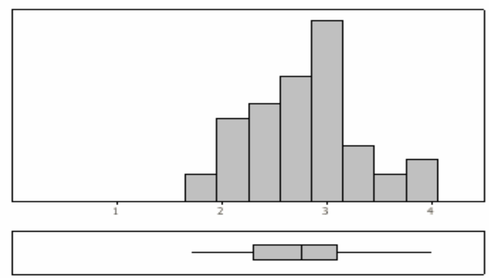
Maximum = 2.8
3rd Quartile = 2.1
Median = 1.9
1st Quartile = 1.7
Minimum = 1.1
N = 64



Maximum = 3.9
3rd Quartile = 3.3
Median = 3.0
1st Quartile = 2.7
Minimum = 2.1
N = 63



Maximum = 4.0
3rd Quartile = 3.1
Median = 2.8
1st Quartile = 2.4
Minimum = 1.5
N = 64

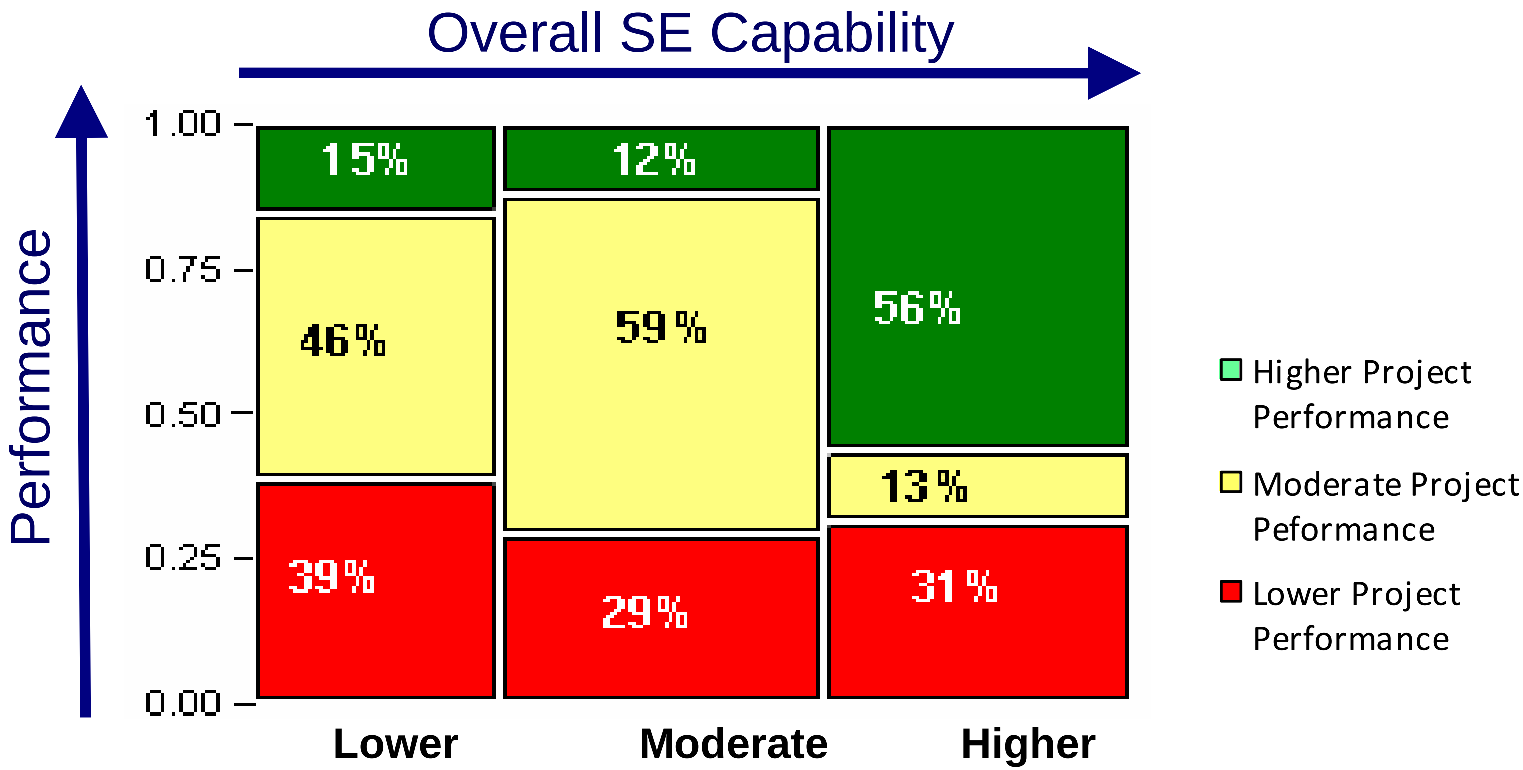


Maximum = 4.0
3rd Quartile = 3.1
Median = 2.75
1st Quartile = 2.3
Minimum = 1.7
N = 46

Analyzed distributions, variability, relationships…
To ensure statistical rigor and relevance

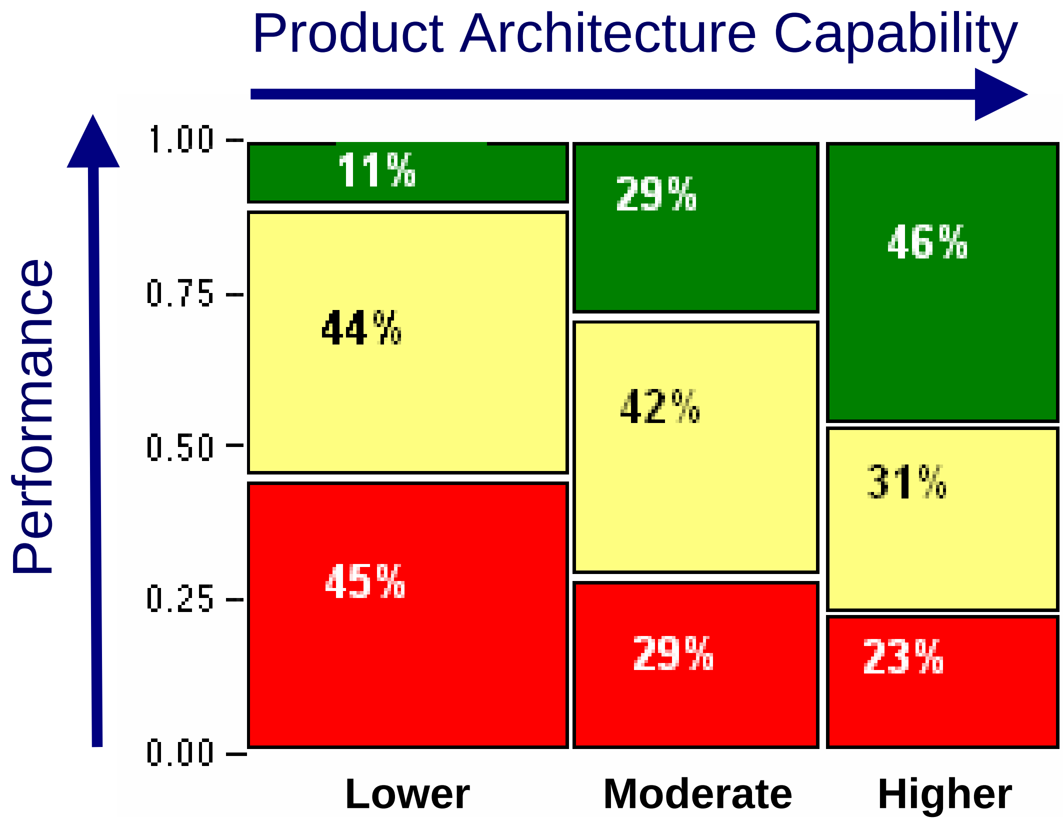
Results

Overall SE Capability & Project Performance



Projects with better <u>Overall Systems Engineering Capability</u> delivers better Project Performance *(cost, schedule and scope)*

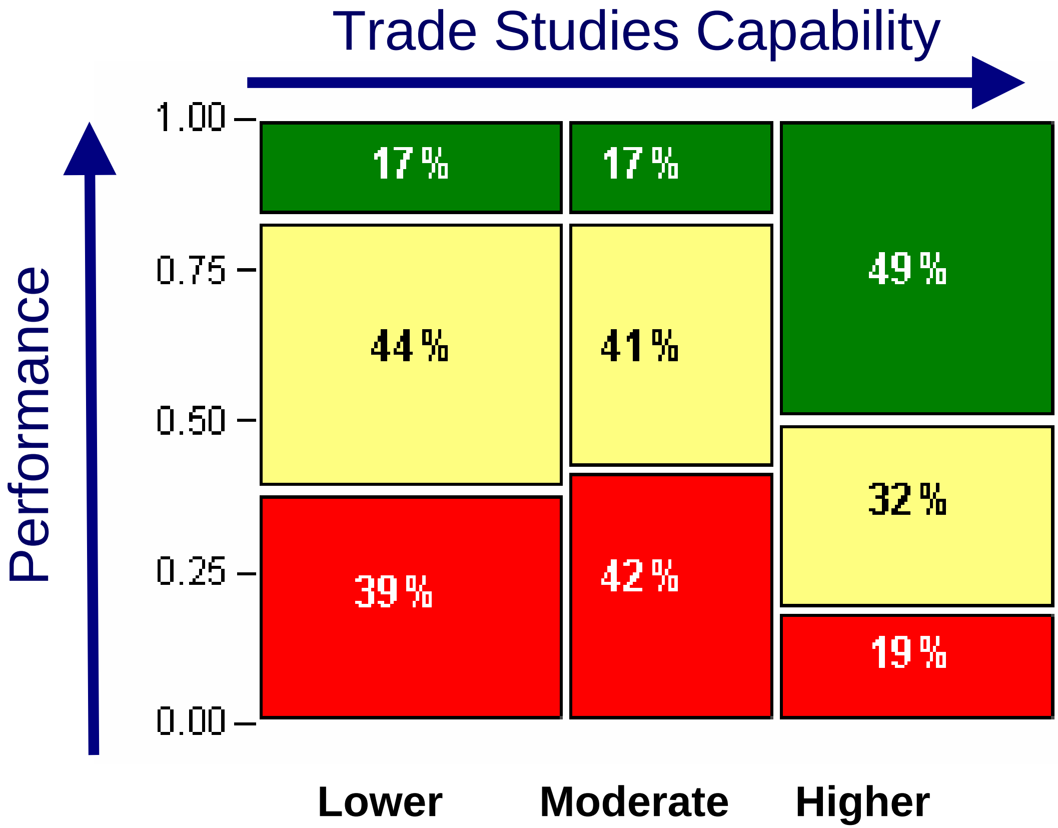
1. Product Architecture and Project Performance



Projects with better <u>Product Architecture</u> Capability Show a "<u>Moderately Strong / Strong</u>" <u>Positive Relationship</u> with Performance

Results

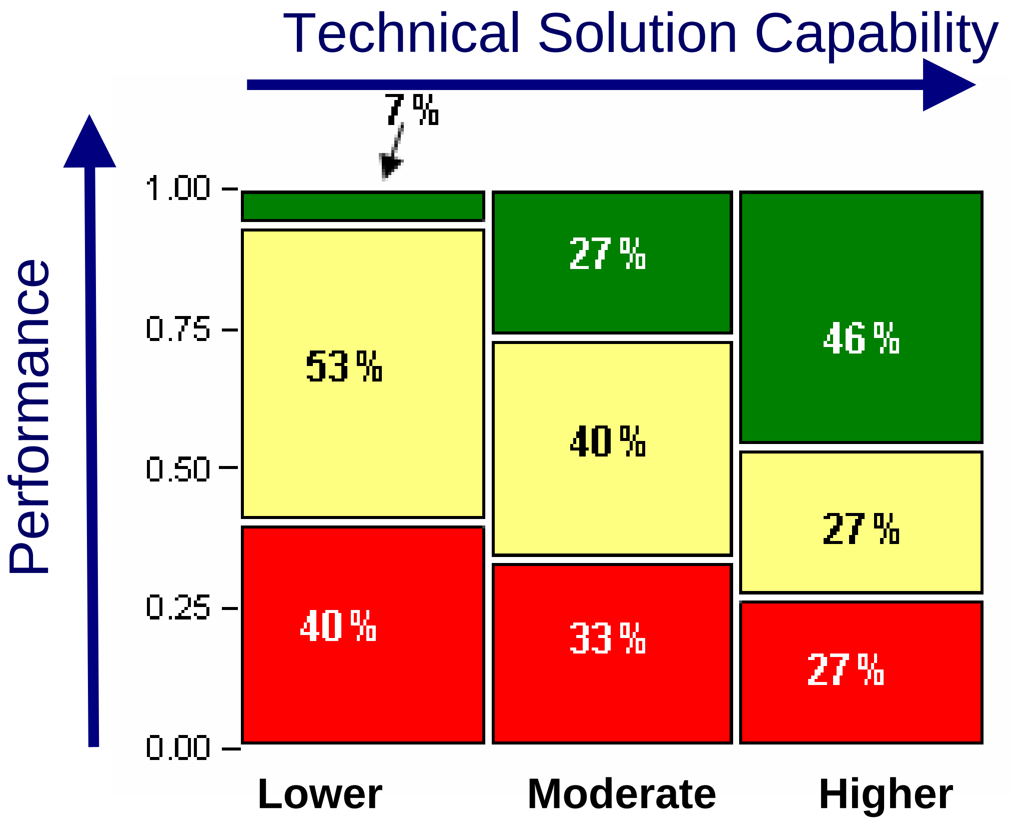
2. Trade Studies and Project Performance



Projects with better <u>Trade Studies</u> Capability Show a <u>"Moderately Strong / Strong" Positive Relationship</u> with Performance

Results

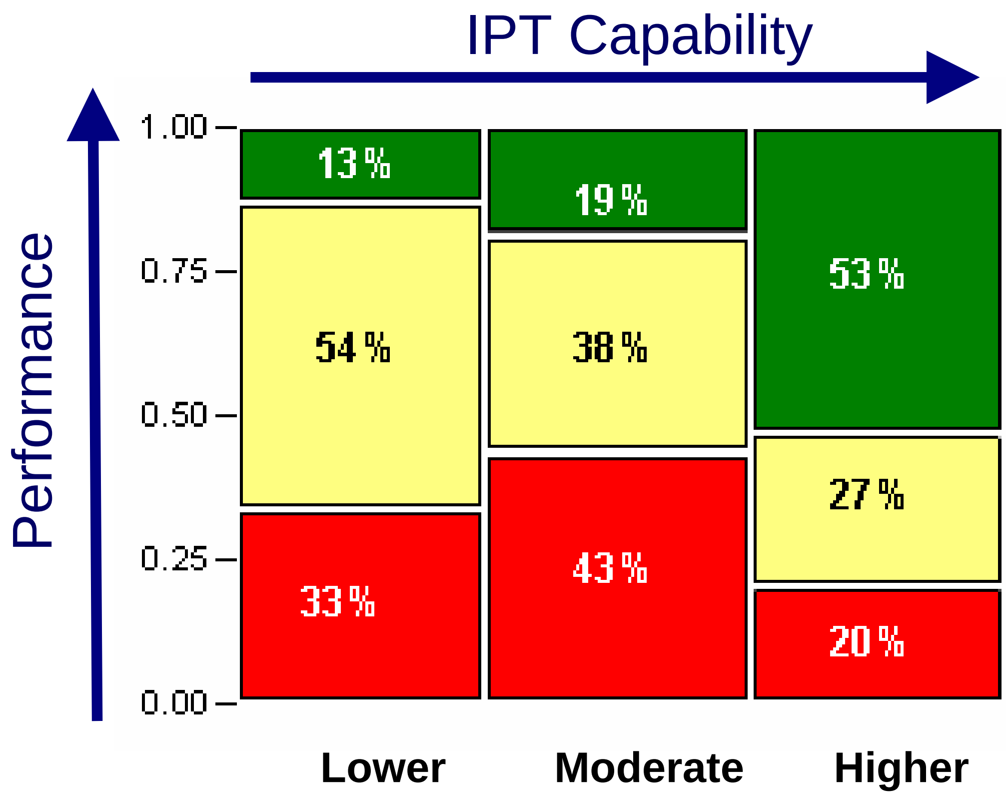
3. Technical Solution and Project Performance



Projects with better <u>Technical Solution</u> Capability Show a <u>"Moderately Strong / Strong" Positive Relationship</u> with Performance

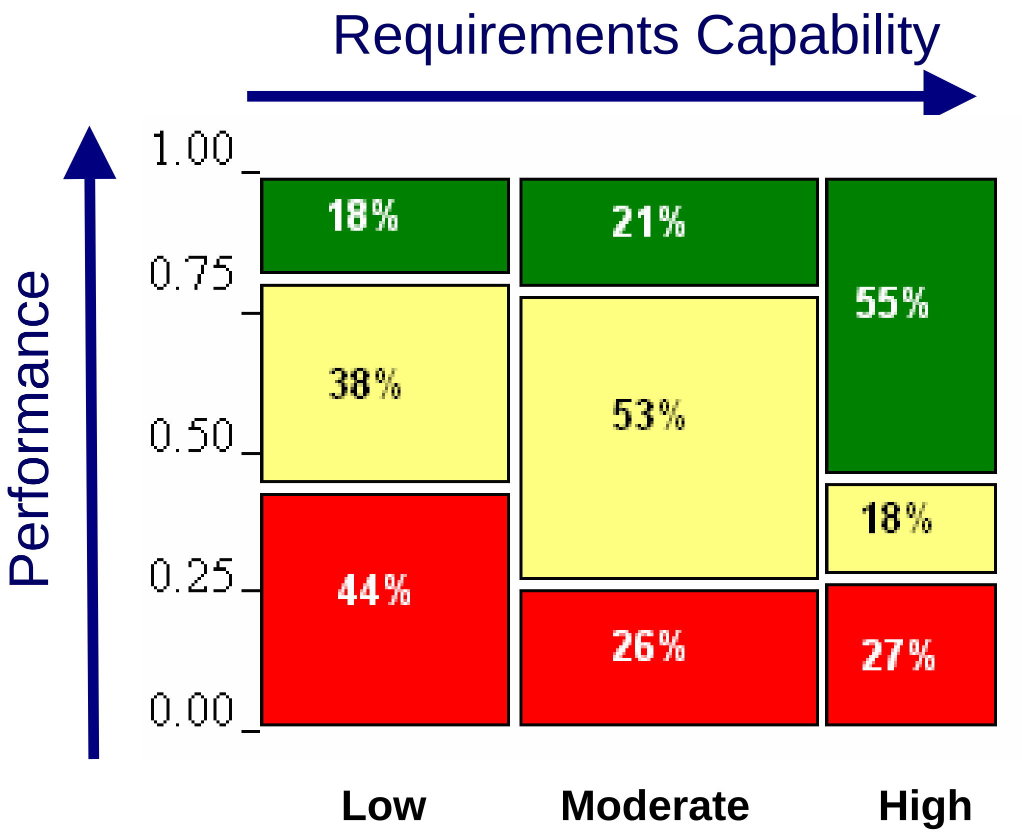
Results

4. IPTs and Project Performance



Projects with better <u>IPTs</u> Capability
Show a <u>“Moderately Strong / Strong” Positive Relationship</u>
with Performance

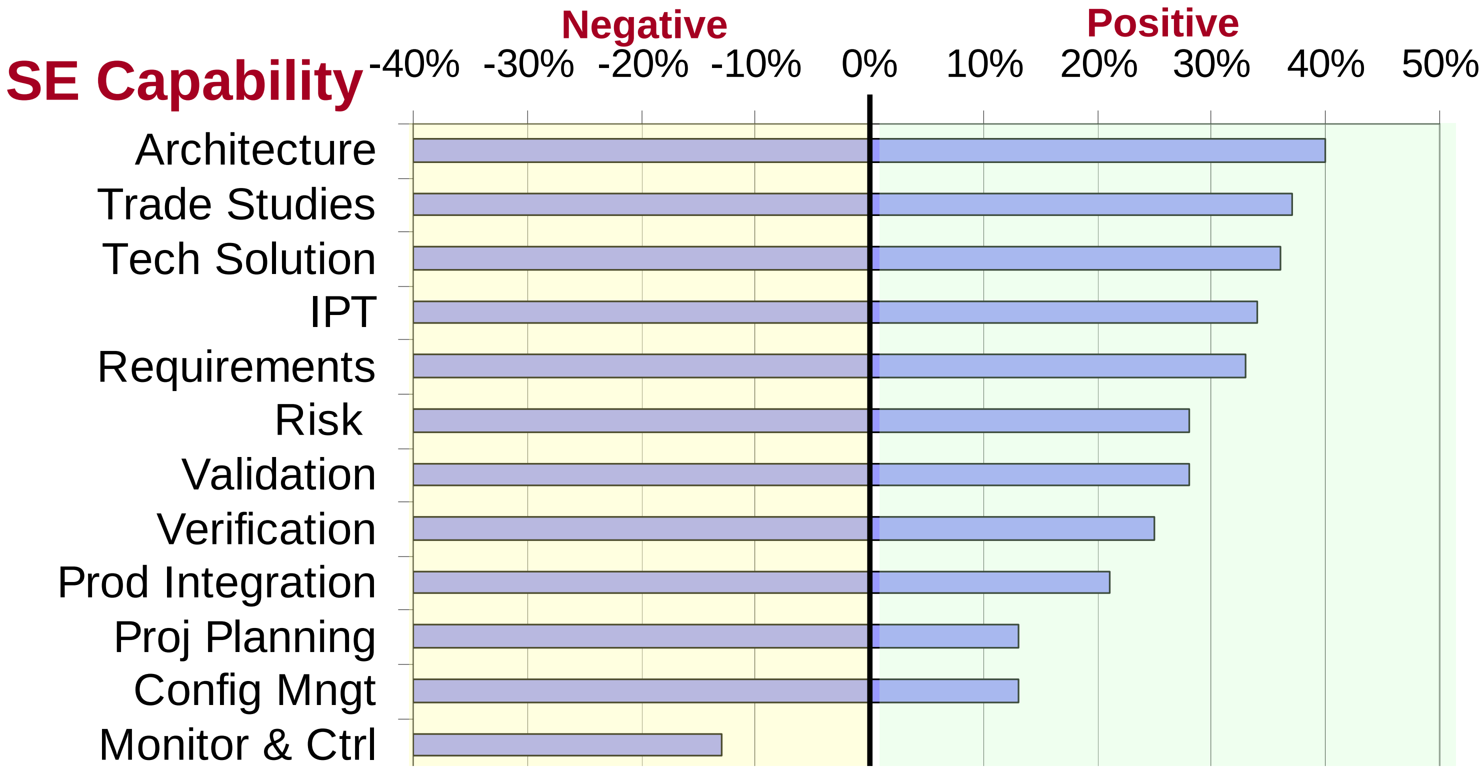
5. Requirements and Project Performance



Projects with better <u>Requirements Management and Development Capability</u> Show a <u>"Moderately Strong / Strong" Positive Relationship</u> with Performance

Results

Summary of Relationships



Relationship to Performance (Gamma)

Conclusions & Caveats

Summary

SE Effectiveness

- Provides credible measured evidence about the value of disciplined Systems Engineering
- Affects success of systems-development projects

Specific Systems Engineering Best Practices

- Highest relationships to activities on the “left side of SE Vee”

Environment (Project Challenge) affects performance too

- Some projects are more challenging than others ... and higher challenge affects performance negatively
- Yet good SE practices remain crucial for both high and low challenge projects

Conclusions & Caveats

Next Steps

- **Correlate Report Findings with Other Sources**
- **Develop Improvement Recommendations**
  - Policy, guidance, training, measures, reviews
- **Conduct Additional Analysis of Collected Data**
  - IV & V
  - Discover other relationships and correlations
- **Repeat the Survey to Gauge Improvements**
- **Survey Acquirers**

Acknowledgements

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Gerald Miller	Mike Phillips	Dave Zubrow	Larry Farrell		

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Backup

NDIA SE Effectiveness Survey Analysis Slides

Reference: "A Survey of Systems Engineering Effectiveness", Software Engineering Institute, Carnegie Mellon University, CMU/SEI-2007-SR-008. Joseph P. Elm, Dennis R. Goldenson, Khaled El Emam, Nicole Donatelli, Angelica Nissa.

Conclusions & Caveats

Consistent with "Top 10 Reasons Projects Fail"*

1. Lack of user involvement
2. Changing requirements
3. Inadequate Specifications
4. Unrealistic project estimates
5. Poor project management
6. Management change control
7. Inexperienced personnel
8. Expectations not properly set
9. Subcontractor failure
10. Poor architectural design

Above Items Can Cause Overall Program Cost and Schedule to Overrun

*** Project Management Institute**

Matching items noted in RED

Conclusions & Caveats

Consistent with "Top 5 SE Issues" (2006)*

- **Key systems engineering practices known to be effective are not consistently applied across all phases of the program life cycle.**

- **Insufficient systems engineering is applied early in the program life cycle, compromising the foundation for initial requirements and architecture development.**

- **Requirements are not always well-managed, including the effective translation from capabilities statements into executable requirements to achieve successful acquisition programs.**

- **The quantity and quality of systems engineering expertise is insufficient to meet the demands of the government and the defense industry.**

- **Collaborative environments, including SE tools, are inadequate to effectively execute SE at the joint capability, system of systems, and system levels.**

*** OUSD AT&L Summit**

Matching items noted in RED

Summary SE Relationships to Project Performance

Relative Project Performance

Details

			Lower					Moderate					Higher				
	Gamma	p	Min. Range	# Lo	# Med	# Hi	Max. Range	Min. Range	# Lo	# Med	# Hi	Max. Range	Min. Range	# Lo	# Med	# Hi	Max. Range
Project Challenge																	
PC	-31%	5.0%	1.0	22%	28%	50%	1.85	1.85	42%	58%	0%	2.05	2.05	38%	38%	25%	4.0
Project Environment																	
CMMI	22%	13.0%	1.0	36%	57%	7%	1.95	1.95	29%	36%	35%	2.7	2.7	33%	28%	39%	4.0
IMP	5%	39.0%	1.0	25%	55%	20%	2.17	2.17	42%	29%	29%	2.84	2.84	33%	25%	42%	4.0
EXP	9%	33.0%	1.0	29%	42%	29%	2.5	2.5	39%	44%	17%	3.5	3.5	29%	29%	42%	4.0
Systems Engineering Capability																	
IPT	34%	4.0%	1.0	33%	54%	13%	2.5	2.5	43%	38%	19%	3.1	3.1	20%	27%	53%	4.0
PP	13%	25.0%	1.0	33%	54%	13%	2.8	2.8	29%	35%	36%	3.3	3.3	35%	29%	36%	4.0
PMC	-13%	25.0%	1.0	23%	54%	23%	2.5	2.5	23%	46%	31%	3.0	3.0	45%	25%	30%	4.0
RSKM	28%	6.1%	1.0	35%	47%	18%	2.8	2.8	27%	66%	7%	3.6	3.6	36%	0%	64%	4.0
REQ	33%	4.0%	1.0	44%	38%	18%	2.8	2.8	26%	53%	21%	3.4	3.4	27%	18%	55%	4.0
TRADE	37%	3.0%	1.0	39%	44%	17%	2.7	2.7	42%	41%	17%	3.3	3.3	19%	32%	49%	4.0
ARCH	40%	0.2%	1.0	45%	44%	11%	2.7	2.7	29%	42%	29%	3.3	3.3	23%	31%	46%	4.0
TS	36%	3.0%	1.0	40%	53%	7%	2.8	2.8	33%	40%	27%	3.2	3.2	27%	27%	46%	4.0
PI	21%	16.0%	1.0	36%	54%	14%	1.5	1.5	33%	38%	29%	3.5	3.5	29%	29%	42%	4.0
VER	25%	9.0%	1.0	31%	62%	7%	2.7	2.7	33%	34%	33%	3.2	3.2	33%	20%	47%	4.0
VAL	28%	7.0%	1.0	54%	23%	23%	2.7	2.7	17%	66%	17%	3.3	3.3	29%	33%	38%	4.0
CM	13%	26.0%	1.0	29%	47%	24%	3.0	3.0	46%	36%	18%	3.67	3.67	28%	33%	39%	4.0
Overall SEC	32%	4.0%	1.0	39%	46%	15%	2.5	2.5	29%	59%	12%	3.0	3.0	31%	13%	56%	4.0
REQ+TS	49%	0.5%	1.0	43%	50%	13%	2.8	2.8	23%	62%	15%	3.1	3.1	22%	28%	50%	4.0
Acquirer Capability																	
AC	-35%	3.0%	1.0	7%	60%	33%	2.5	2.5	41%	32%	26%	3.0	3.0	50%	25%	25%	4.0
Combined Capability and Challenge																	
REQ+TS+PC	63%	0.0%	1.0	67%	33%	0%	1.7	1.7	25%	45%	30%	2.3	2.3	14%	36%	50%	4.0

Gamma relationship	Chance probability
Strong	Very low
Moderately strong to strong	Low
Moderately strong	Moderately low
Weak	Fair

Summary SE Relationships to Project Performance

Relative Project Performance

Details

	Gamma	p	Lower Min. Range	Lower # Lo	Lower # Med	Lower # Hi	Lower Max. Range	Moderate Min. Range	Moderate # Lo	Moderate # Med	Moderate # Hi	Moderate Max. Range	Higher Min. Range	Higher # Lo	Higher # Med	Higher # Hi	Higher Max. Range
Project Challenge																	
PC	-31%	5.0%	1.0	22%	28%	50%	1.85	1.85	42%	58%	0%	2.05	2.05	38%	38%	25%	4.0
Project Environment																	
CMMI	22%	13.0%	1.0	36%													
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IPT	34%	4.0%	1.0	33%	54%	13%	2.5	2.5	43%	38%	19%	3.1	3.1	20%	27%	53%	4.0
PP	13%	25.0%	1.0	33%	54%	13%	2.8	2.8	29%	35%	36%	3.3	3.3	35%	29%	36%	4.0
PMC	-13%	25.0%	1.0	23%	54%	23%	2.5	2.5	23%	46%	31%	3.0	3.0	45%	25%	30%	4.0
RSKM	28%	6.1%	1.0	35%	47%	18%	2.8	2.8	27%	66%	7%	3.6	3.6	36%	0%	64%	4.0
REQ	33%	4.0%	1.0	44%	38%	18%	2.8	2.8	26%	53%	21%	3.4	3.4	27%	18%	55%	4.0
TRADE	37%	3.0%	1.0	39%	44%	17%	2.7	2.7	42%	41%	17%	3.3	3.3	19%	32%	49%	4.0
ARCH	40%	0.2%	1.0	45%	44%	11%	2.7	2.7	29%	42%	29%	3.3	3.3	23%	31%	46%	4.0
TS	36%	3.0%	1.0	40%	53%	7%	2.8	2.8	33%	40%	27%	3.2	3.2	27%	27%	46%	4.0
PI	21%	16.0%	1.0	36%	54%	14%	1.5	1.5	33%	38%	29%	3.5	3.5	29%	29%	42%	4.0
VER	25%	9.0%	1.0	31%	62%	7%	2.7	2.7	33%	34%	33%	3.2	3.2	33%	20%	47%	4.0
VAL	28%	7.0%	1.0	54%	23%	23%	2.7	2.7	17%	66%	17%	3.3	3.3	29%	33%	38%	4.0
CM	13%	26.0%	1.0	29%	47%	24%	3.0	3.0	46%	36%	18%	3.67	3.67	28%	33%	39%	4.0
Overall SEC	32%	4.0%	1.0	39%	46%	15%	2.5	2.5	29%	59%	12%	3.0	3.0	31%	13%	56%	4.0
REQ+TS	49%	0.5%	1.0	43%	50%	13%	2.8	2.8	23%	62%	15%	3.1	3.1	22%	28%	50%	4.0
Acquirer Capability																	
AC	-35														25%	25%	4.0
Combined Capability and																	
REQ+TS+PC	63														36%	50%	4.0

Highest scoring SE capability areas in Higher Performing Projects*: Risk Management; Requirements Development and Management; IPTs

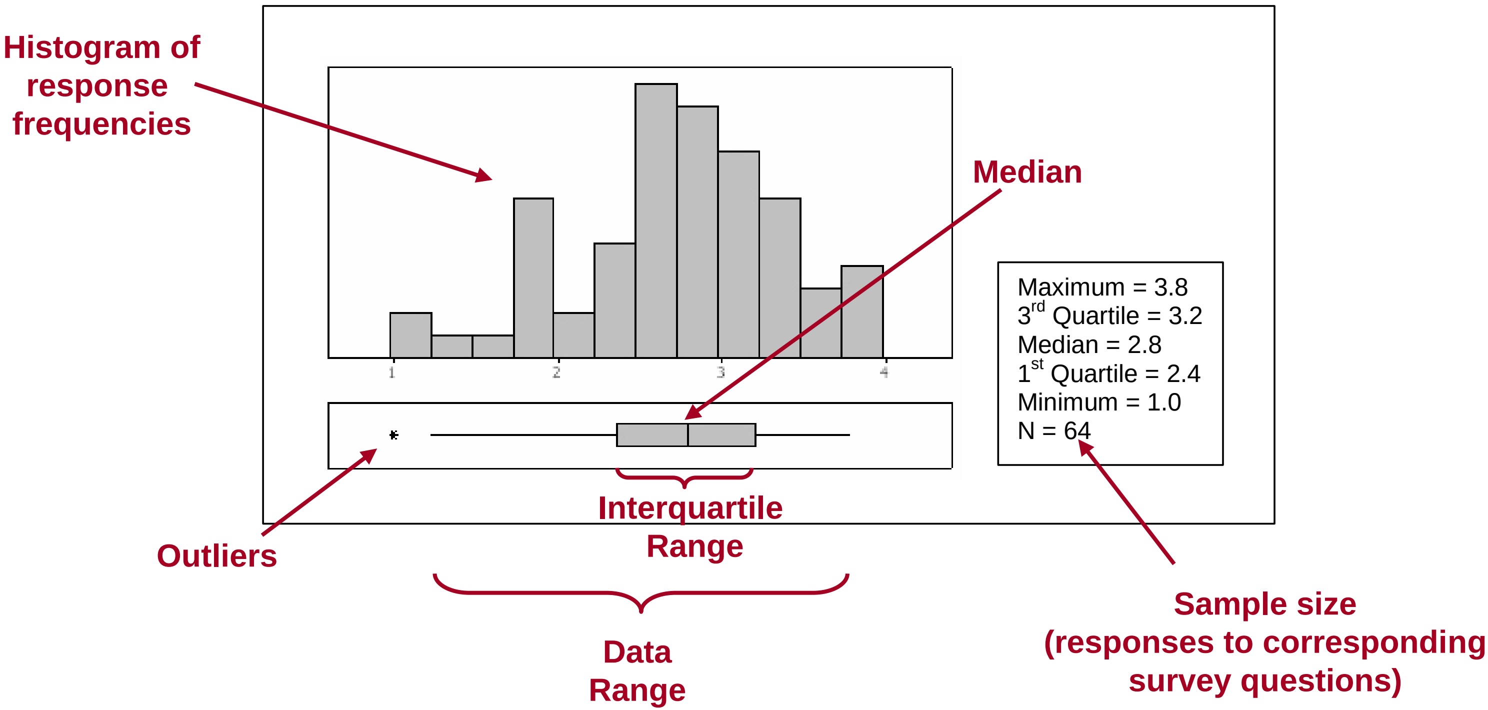
*Based on small partitioned sample size

Lowest scoring SE capability areas in Lower Performing Projects*: Validation; Architecture; Requirements Development and Management

	Gamma relationship	Chance probability
(blue)	Strong	Very low
(green)	Moderately strong to strong	Low
(orange)	Moderately strong	Moderately low
(yellow)	Weak	Fair

Terminology and Notation

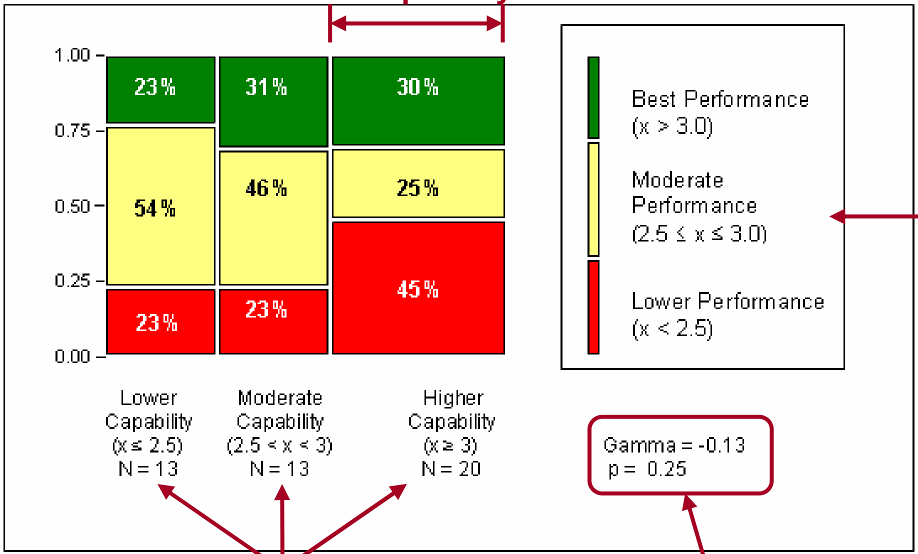
Distribution Graph



Terminology and Notation

Mosaic Chart

Column width represents proportion of projects with this level of capability



Relative performance distribution of the sample

Projects exhibiting a given level of relative capability (Lowest, Intermediate, Highest)

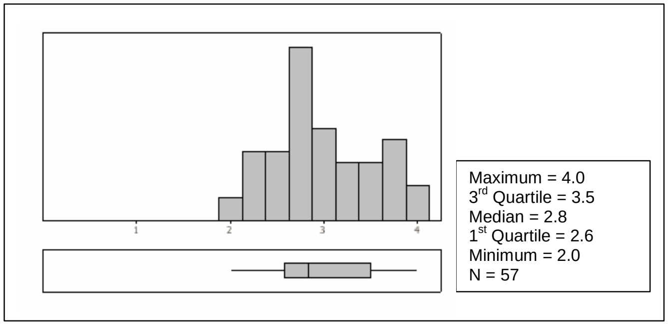
Sample size and distribution for associated survey responses (capability + performance)

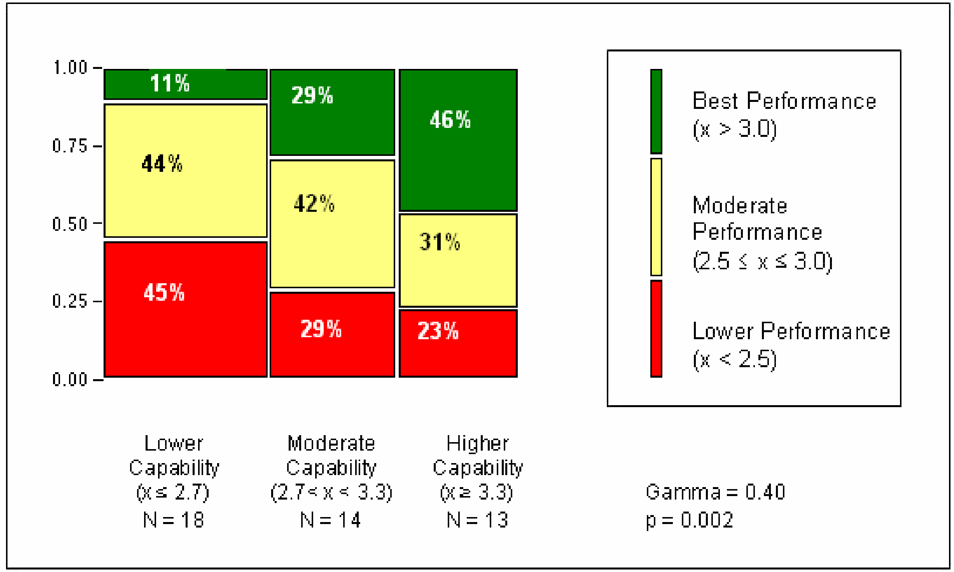
Measures of association and statistical test

<u>Gamma</u>: measures strength of relationship between two ordinal variables

<u>p</u>: probability that an associative relationship would be observed by chance alone

SE Capability:
Product Architecture (ARCH)





Relationship to project performance:	Moderately strong to strong positive relationship

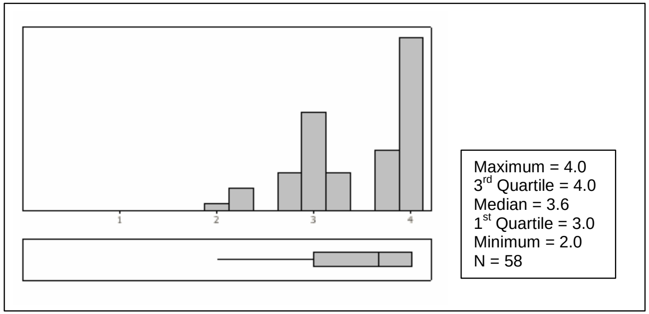
SE Capability

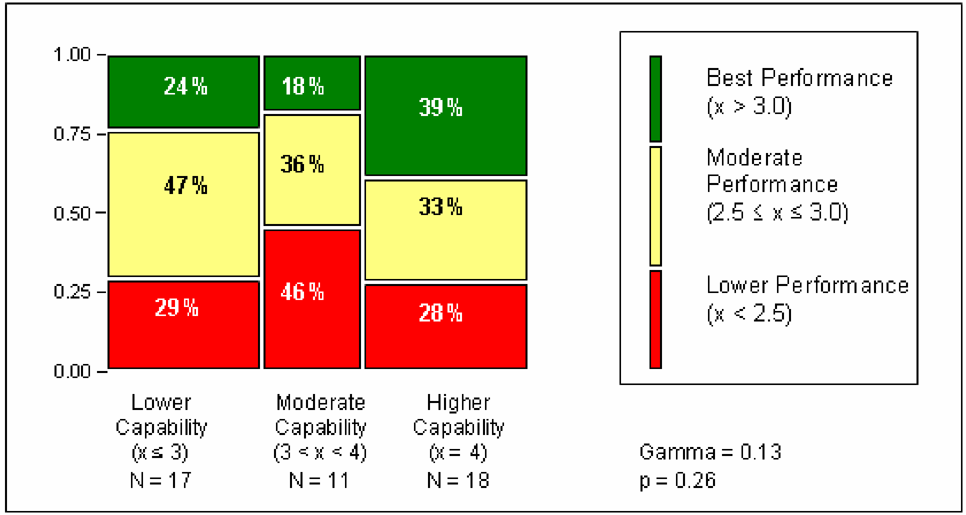
			Lower					Moderate					Higher				
	Gamma	p	Min. Range	# Lo	# Med	# Hi	Max. Range	Min. Range	# Lo	# Med	# Hi	Max. Range	Min. Range	# Lo	# Med	# Hi	Max. Range
ARCH	40%	0.2%	1.0	45%	44%	11%	2.7	2.7	29%	42%	29%	3.3	3.3	23%	31%	46%	4.0

Survey Questions

ID	Question	Response range
IF01	This project maintains accurate and up-to-date descriptions (e.g. interface control documents, models, etc.) defining interfaces in detail	•strongly disagree •disagree •agree •strongly agree
IF02	Interface definition descriptions are maintained in a designated location, under configuration management, and accessible to all who need them	•strongly disagree •disagree •agree •strongly agree
IF03a	For this project, the product high-level structure is documented, kept up to date, and managed under configuration control	•strongly disagree •disagree •agree •strongly agree
IF03b	For this project, the product high-level structure is documented using multiple views (e.g. functional views, module views, etc.	•strongly disagree •disagree •agree •strongly agree
IF03c	For this project, the product high-level structure is accessible to all relevant project personnel	•strongly disagree •disagree •agree •strongly agree
IF04	This project has defined and documented guidelines for choosing COTS product components	•strongly disagree •disagree •agree •strongly agree

SE Capability:
Configuration Management (CM)





Relationship to project performance:	Weak positive relationship

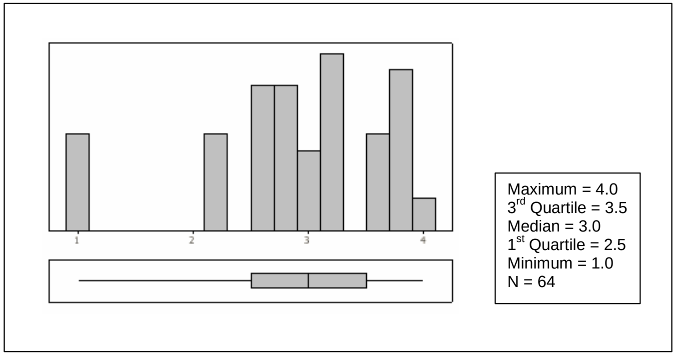
SE Capability

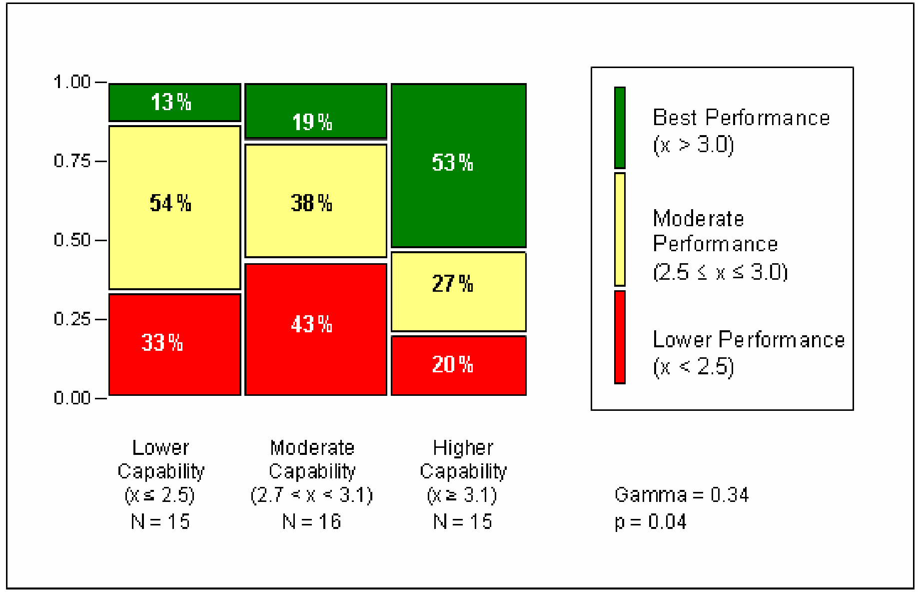
	Gamma	p	Lower					Moderate					Higher				
			Min. Range	# Lo	# Med	# Hi	Max. Range	Min. Range	# Lo	# Med	# Hi	Max. Range	Min. Range	# Lo	# Med	# Hi	Max. Range
CM	13%	26.0%	1.0	29%	47%	24%	3.0	3.0	46%	36%	18%	3.67	3.67	28%	33%	39%	4.0

Survey Questions

ID	Question	Response Range
V&V06	This project has a configuration management system that charters a Change Control Board to disposition change requests	•strongly disagree •disagree •agree •strongly agree
V&V07	This project maintains records of requested and implemented changes to configuration-managed items	•strongly disagree •disagree •agree •strongly agree
V&V08	This project creates and manages configuration baselines (e.g., functional, allocated, product)	•strongly disagree •disagree •agree •strongly agree

SE Capability:
IPT-Related Capability (IPT)





Relationship to project performance:	Moderately strong positive relationship

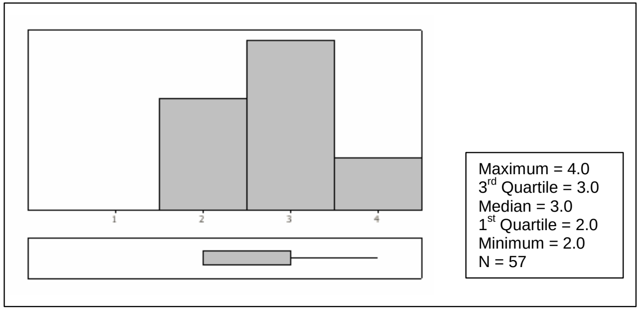
SE Capability

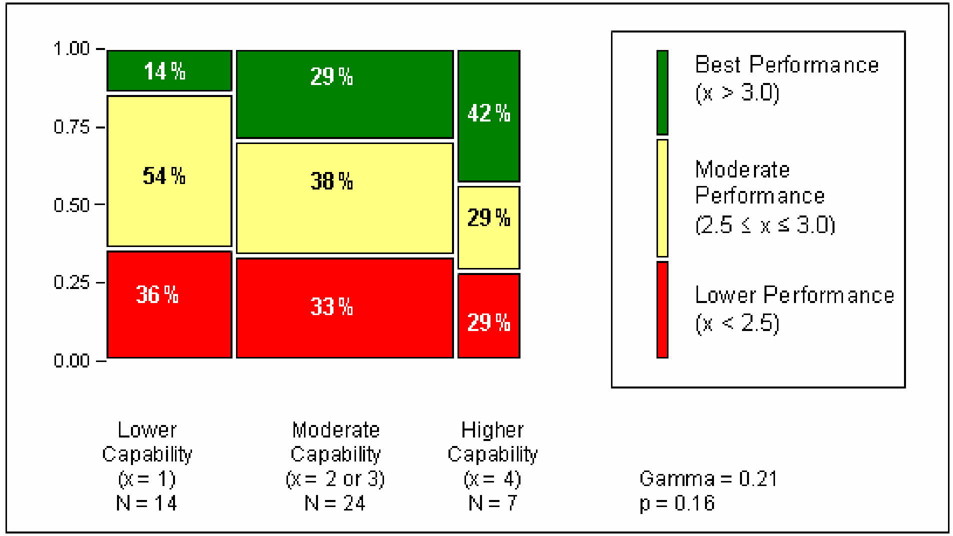
	Gamma	p	Lower					Moderate					Higher				
			Min. Range	# Lo	# Med	# Hi	Max. Range	Min. Range	# Lo	# Med	# Hi	Max. Range	Min. Range	# Lo	# Med	# Hi	Max. Range
IPT	34%	4.0%	1.0	33%	54%	13%	2.5	2.5	43%	38%	19%	3.1	3.1	20%	27%	53%	4.0

Survey Questions

ID	Question	Response range
Proj03	This project uses integrated product teams (IPTs)	•Yes •No
Proj04	This project makes effective use of integrated product teams (IPTs)	•highly compliant •largely compliant; •moderately compliant •not compliant
Proj06	My suppliers actively participate in IPTs	•highly compliant •largely compliant; •moderately compliant •not compliant
Proj07a	This project has an IPT with assigned responsibility for systems engineering	•highly compliant •largely compliant; •moderately compliant •not compliant
Proj07b	This project has Systems Engineering representation on each IPT	•highly compliant •largely compliant; •moderately compliant •not compliant

SE Capability:
Product Integration (PI)





Relationship to project performance:	Weak positive relationship

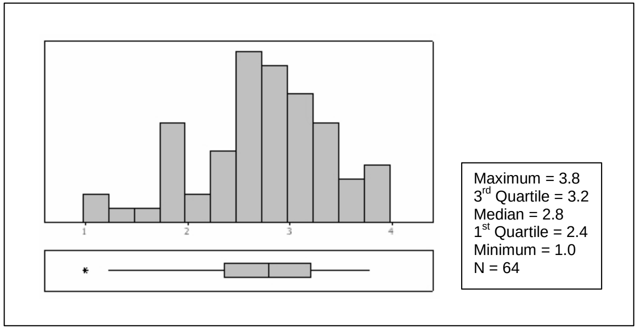
SE Capability

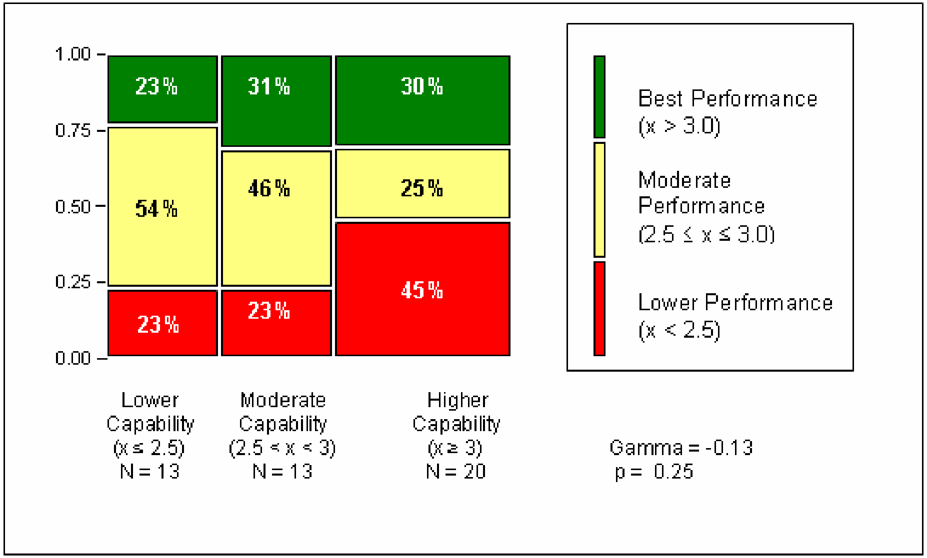
			Lower					Moderate					Higher				
	Gamma	p	Min. Range	# Lo	# Med	# Hi	Max. Range	Min. Range	# Lo	# Med	# Hi	Max. Range	Min. Range	# Lo	# Med	# Hi	Max. Range
PI	21%	16.0%	1.0	36%	54%	14%	1.5	1.5	33%	38%	29%	3.5	3.5	29%	29%	42%	4.0

Survey Question

ID	Question	Response range
IF05	This project has accurate and up-to-date documents defining its product integration process, plans, criteria, etc. throughout the life cycle	•strongly disagree •disagree •agree •strongly agree

SE Capability:
Project Monitoring and Control (PMC)





Relationship to project performance:	Weak negative relationship

SE Capability

	Gamma	p	Lower Min. Range	Lower # Lo	Lower # Med	Lower # Hi	Lower Max. Range	Moderate Min. Range	Moderate # Lo	Moderate # Med	Moderate # Hi	Moderate Max. Range	Higher Min. Range	Higher # Lo	Higher # Med	Higher # Hi	Higher Max. Range
PMC	-13%	25.0%	1.0	23%	54%	23%	2.5	2.5	23%	46%	31%	3.0	3.0	45%	25%	30%	4.0

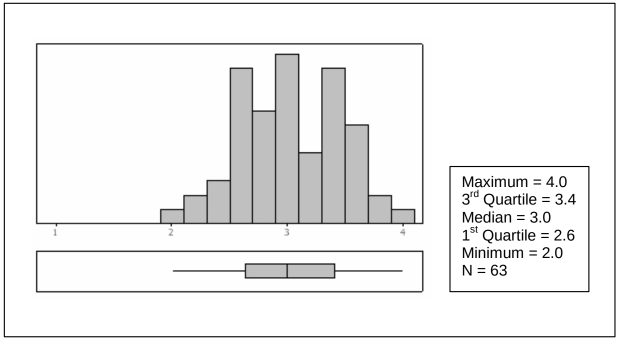
Survey Questions (Part 1)

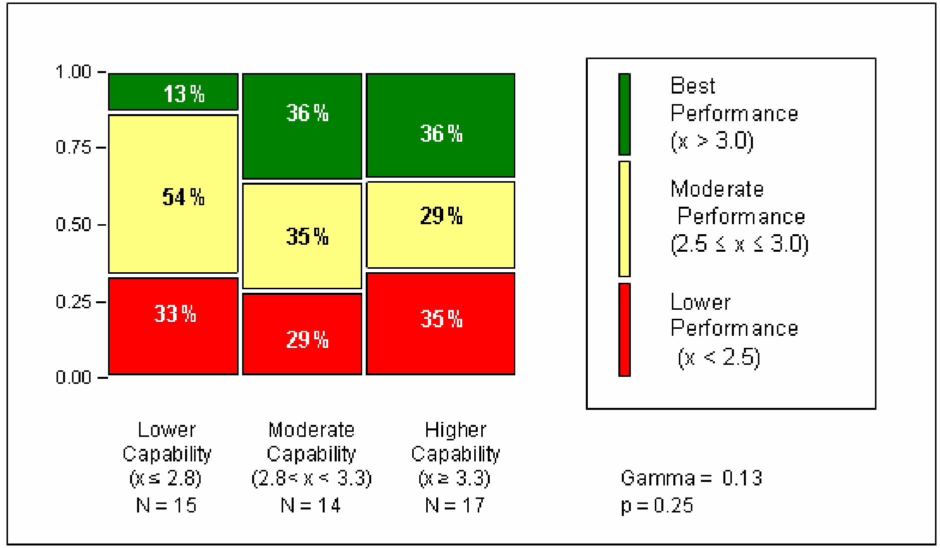
ID	Question	Response range
Cont13	Do you separately cost and track systems engineering activities?	Yes No
Cont14a	Approximately what percentage of non-recurring engineering (NRE) does systems engineering represent?	Percentages quantized as: •<= 5% •<= 10% •<= 15% •<= 25% •> 25%
Cont14b	Is the NRE percentage estimated, or is it a measured value?	•estimated •measured
Perf01	This project creates and manages cost and schedule baselines	•strongly disagree •disagree •agree •strongly agree
Perf02b	EVMS data are available to decision makers in a timely manner (i.e. current within 2 weeks)	•strongly disagree •disagree •agree •strongly agree
Perf02c	The requirement to track and report EVMS data is levied upon the project's suppliers	•strongly disagree •disagree •agree •strongly agree
Perf02d	Variance thresholds for CPI and SPI variance are defined, documented, and used to determine when corrective action is needed	•strongly disagree •disagree •agree •strongly agree

Survey Questions (Part 2)

ID	Question	Response range	
Perf02e	EVMS is linked to the technical effort through the WBS and the IMP/IMS	•strongly disagree •disagree •agree •strongly agree	
OPerf05	Does this project track reports of problems from fielded items?	•Yes •No	Scored by the number of positive responses
OPerf06	Does the project conduct an engineering assessment of all field trouble reports?	•Yes •No	
OPerf07	The results of this engineering assessment feed into …	•operational hazard risk assessments •materiel readiness assessments •system upgrades planning •other	

SE Capability:
Project Planning (PP)





Relationship to project performance:	Weak positive relationship

SE Capability

	Gamma	p	Lower: Min. Range	Lower: # Lo	Lower: # Med	Lower: # Hi	Lower: Max. Range	Moderate: Min. Range	Moderate: # Lo	Moderate: # Med	Moderate: # Hi	Moderate: Max. Range	Higher: Min. Range	Higher: # Lo	Higher: # Med	Higher: # Hi	Higher: Max. Range
PP	13%	25.0%	1.0	33%	54%	13%	2.8	2.8	29%	35%	36%	3.3	3.3	35%	29%	36%	4.0

Survey Questions (Part 1)

ID	Question	Response range
PD01	This project utilizes a documented set of systems engineering processes for the planning and execution of the project	•strongly disagree •disagree •agree •strongly agree
PD02a	This project has an accurate and up-to-date Work Breakdown Structure (WBS) that includes task descriptions and work package descriptions	•strongly disagree •disagree •agree •strongly agree
PD02b	This project has an accurate and up-to-date Work Breakdown Structure (WBS) that is based upon the product structure	•strongly disagree •disagree •agree •strongly agree
PD02c	This project has an accurate and up-to-date Work Breakdown Structure (WBS) that is developed with the active participation of those who perform the systems engineering activities	•strongly disagree •disagree •agree •strongly agree
PD02d	This project has an accurate and up-to-date Work Breakdown Structure (WBS) that is developed with the active participation of all relevant stakeholders, e.g., developers, maintainers, testers, inspectors, etc.	•strongly disagree •disagree •agree •strongly agree
PD03a	This project's Technical Approach (i.e. a top-level strategy and methodology to create the initial conceptual design for product development) is complete, accurate and up-to-date	•strongly disagree •disagree •agree •strongly agree
PD03b	This project's Technical Approach (i.e. a top-level strategy and methodology to create the initial conceptual design for product development) is developed with the active participation of those who perform the systems engineering activities	•strongly disagree •disagree •agree •strongly agree
PD03c	This project's Technical Approach (i.e. a top-level strategy and methodology to create the initial conceptual design for product development) is developed with the active participation of all appropriate functional stakeholder	•strongly disagree •disagree •agree •strongly agree

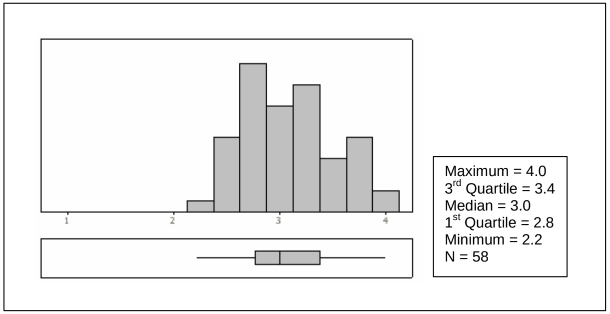
Survey Questions (Part 2)

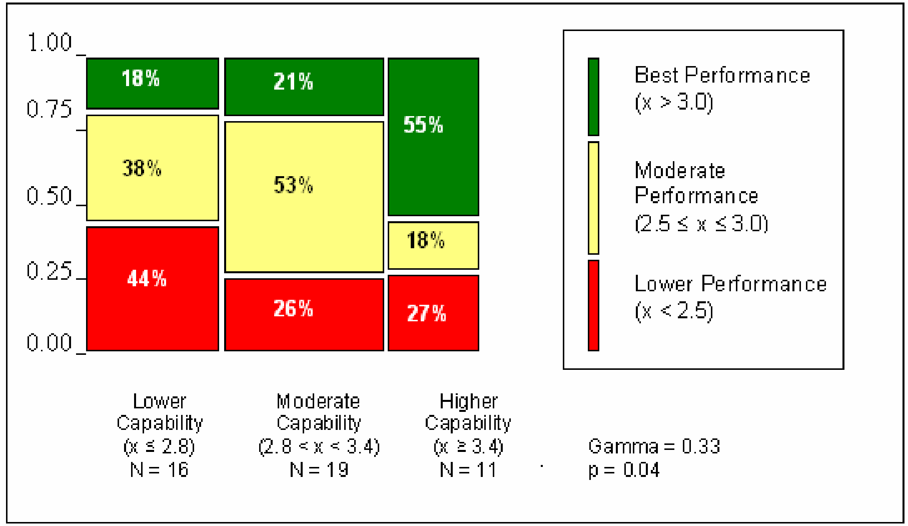
ID	Question	Response range
PD04a	This project has a top-level plan, such as an Integrated Master Plan (IMP), that is an event-driven plan (i.e., each accomplishment is tied to a key project event)	•strongly disagree •disagree •agree •strongly agree
PD04b	This project has a top-level plan, such as an Integrated Master Plan (IMP), that documents significant accomplishments with pass/fail criteria for both business and technical elements of the project	•strongly disagree •disagree •agree •strongly agree
PD04c	This project has a top-level plan, such as an Integrated Master Plan (IMP), that is consistent with the WBS	•strongly disagree •disagree •agree •strongly agree
PD05a	This project has an integrated event-based schedule that is structured as a networked, multi-layered schedule of project tasks required to complete the work effort	•strongly disagree •disagree •agree •strongly agree
PD05b	This project has an integrated event-based schedule that contains a compilation of key technical accomplishments (e.g., a Systems Engineering Master Schedule)	•strongly disagree •disagree •agree •strongly agree
PD05c	This project has an integrated event-based schedule that references measurable criteria (usually contained in the Integrated Master Plan) required for successful completion of key technical accomplishments	•strongly disagree •disagree •agree •strongly agree
PD05d	This project has an integrated event-based schedule that is consistent with the WBS	•strongly disagree •disagree •agree •strongly agree

Survey Questions (Part 3)

ID	Question	Response range
PD05e	This project has an integrated event-based schedule that identifies the critical path of the program schedule	•strongly disagree •disagree •agree •strongly agree
PD06	This project has a plan or plans for the performance of technical reviews with defined entry and exit criteria throughout the life cycle of the project	•strongly disagree •disagree •agree •strongly agree
PD07	This project has a plan or plans that include details of the management of the integrated technical effort across the project (e.g., a Systems Engineering Management Plan or a Systems Engineering Plan)	•strongly disagree •disagree •agree •strongly agree
PD08	Those who perform systems engineering activities actively participate in the development and updates of the project planning	•strongly disagree •disagree •agree •strongly agree
PD09	Those who perform systems engineering activities actively participate in tracking/reporting of task progress	•strongly disagree •disagree •agree •strongly agree

SE Capability:
Requirements Development & Mgmt (REQ)





Relationship to project performance:	Moderately strong positive relationship

SE Capability

	Gamma	p	Lower: Min. Range	Lower: # Lo	Lower: # Med	Lower: # Hi	Lower: Max. Range	Moderate: Min. Range	Moderate: # Lo	Moderate: # Med	Moderate: # Hi	Moderate: Max. Range	Higher: Min. Range	Higher: # Lo	Higher: # Med	Higher: # Hi	Higher: Max. Range
REQ	33%	4.0%	1.0	44%	38%	18%	2.8	2.8	26%	53%	21%	3.4	3.4	27%	18%	55%	4.0

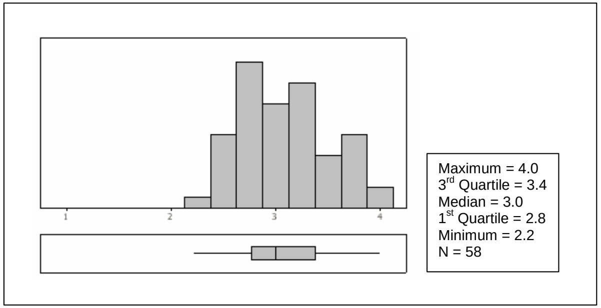
Survey Questions (Part 1)

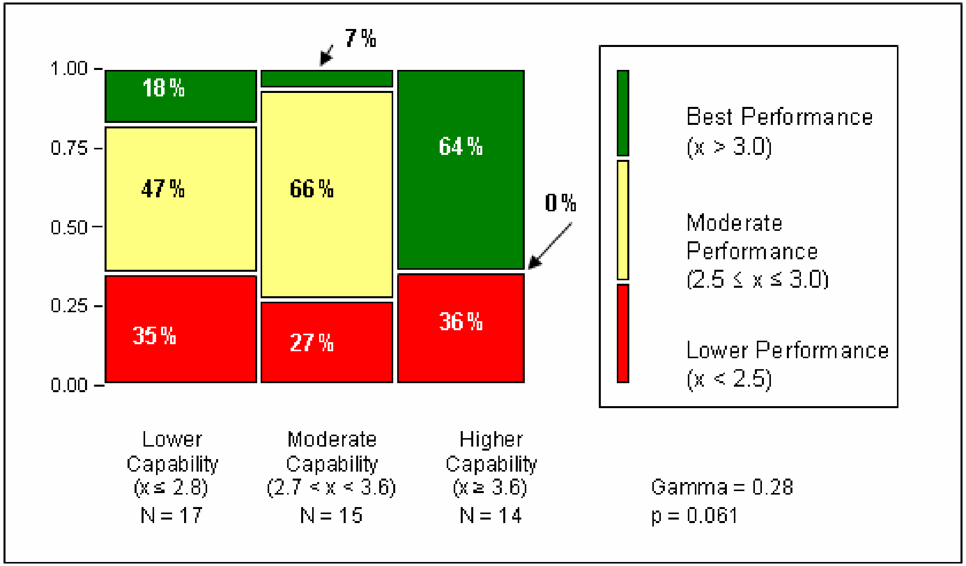
ID	Question	Response range
RD01a	This project maintains an up-to-date and accurate listing of all requirements specified by the customer, to include regulatory, statutory, and certification requirements	•strongly disagree •disagree •agree •strongly agree
RD01b	This project maintains an up-to-date and accurate listing of all requirements derived from those specified by the customer	•strongly disagree •disagree •agree •strongly agree
RD02	This project maintains up-to-date and accurate documentation clearly reflecting the hierarchical allocation of both customer and derived requirements to each element (subsystem, component, etc.) of the system in the configuration baselines	•strongly disagree •disagree •agree •strongly agree
RD03a	This project documents and maintains accurate and up-to-date descriptions of operational concepts and their associated scenarios	•strongly disagree •disagree •agree •strongly agree
RD03b	This project documents and maintains accurate and up-to-date descriptions of use cases (or their equivalent)	•strongly disagree •disagree •agree •strongly agree
RD03c	This project documents and maintains accurate and up-to-date descriptions of product installation, maintenance and support concepts	•strongly disagree •disagree •agree •strongly agree
RD04	This project has documented criteria for identifying authorized requirements providers to avoid requirements creep and volatility	•strongly disagree •disagree •agree •strongly agree

Survey Questions (Part 2)

ID	Question	Response range
RD05	This project has documented criteria (e.g., cost impact, schedule impact, authorization of source, contract scope, requirement quality) for evaluation and acceptance of requirements	•strongly disagree •disagree •agree •strongly agree
RD06	The requirements for this project are approved in a formal and documented manner by relevant stakeholders	•strongly disagree •disagree •agree •strongly agree
RD07	This project performs and documents requirements impact assessments for proposed requirements changes	•strongly disagree •disagree •agree •strongly agree
RD08	This project develops and documents project requirements based upon stakeholder needs, expectations, and constraints	•strongly disagree •disagree •agree •strongly agree
RD09	This project has an accurate and up-to-date requirements tracking system	•strongly disagree •disagree •agree •strongly agree
RD10a	For this project, the requirements documents are managed under a configuration control process	•strongly disagree •disagree •agree •strongly agree
RD10b	For this project, the requirements documents are accessible to all relevant project staff	•strongly disagree •disagree •agree •strongly agree

SE Capability:
Risk Management (RSKM)





Relationship to project performance:	Moderately strong positive relationship

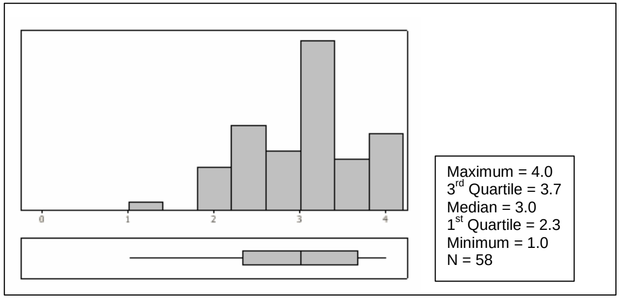
SE Capability

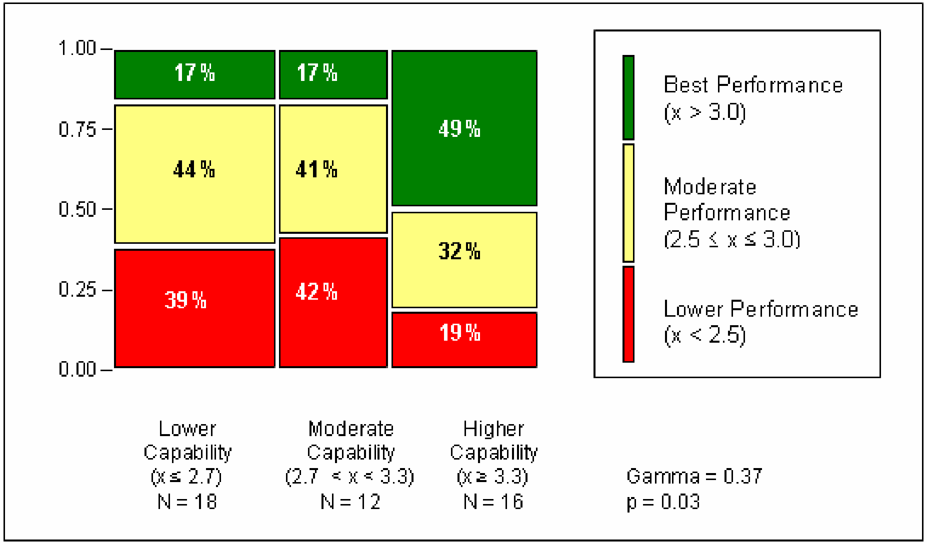
			Lower					Moderate					Higher				
	Gamma	p	Min. Range	# Lo	# Med	# Hi	Max. Range	Min. Range	# Lo	# Med	# Hi	Max. Range	Min. Range	# Lo	# Med	# Hi	Max. Range
RSKM	28%	6.1%	1.0	35%	47%	18%	2.8	2.8	27%	66%	7%	3.6	3.6	36%	0%	64%	4.0

Survey Questions

ID	Question	Response range
PD11a	This project has a Risk Management process that creates and maintains an accurate and up-to-date list of risks affecting the project (e.g., risks to cost, risks to schedule, risks to performance)	•strongly disagree •disagree •agree •strongly agree
PD11b	This project has a Risk Management process that creates and maintains up-to-date documentation of risk mitigation plans and contingency plans for selected risks	•strongly disagree •disagree •agree •strongly agree
PD11c	This project has a Risk Management process that monitors and reports the status of risk mitigation activities and resources	•strongly disagree •disagree •agree •strongly agree
PD11d	This project has a Risk Management process that assesses risk against achievement of an event-based schedule	•strongly disagree •disagree •agree •strongly agree
PD12	This project's Risk Management process is integrated with program decision-making	•strongly disagree •disagree •agree •strongly agree

SE Capability:
Trade Studies (TRADE)





Relationship to project performance:	Moderately strong to strong positive relationship

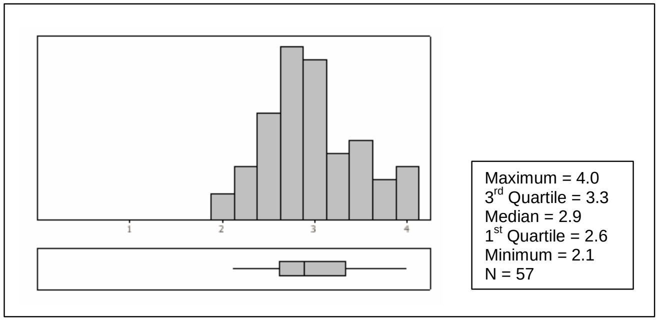
SE Capability

	Gamma	p	Lower Min. Range	Lower # Lo	Lower # Med	Lower # Hi	Lower Max. Range	Moderate Min. Range	Moderate # Lo	Moderate # Med	Moderate # Hi	Moderate Max. Range	Higher Min. Range	Higher # Lo	Higher # Med	Higher # Hi	Higher Max. Range
TRADE	37%	3.0%	1.0	39%	44%	17%	2.7	2.7	42%	41%	17%	3.3	3.3	19%	32%	49%	4.0

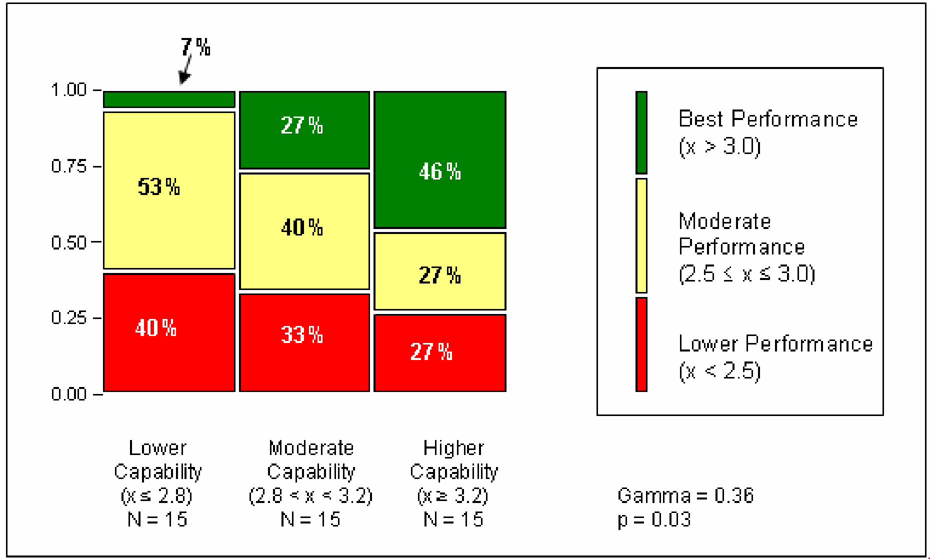
Survey Questions

ID	Question	Response range
RD11	Stakeholders impacted by trade studies are involved in the development and performance of those trade studies	•strongly disagree •disagree •agree •strongly agree
RD12	This project performs and documents trade studies between alternate solutions based upon definitive and documented selection criteria	•strongly disagree •disagree •agree •strongly agree
RD13	Documentation of trade studies is maintained in a defined repository and is accessible to all relevant project staff	•strongly disagree •disagree •agree •strongly agree

SE Capability:
Technical Solution (TS)



Note: TS is a composite measure equivalent to ARCH + TRADE.



Relationship to project performance:	Moderately strong positive relationship

SE Capability

			Lower					Moderate					Higher				
	Gamma	p	Min. Range	# Lo	# Med	# Hi	Max. Range	Min. Range	# Lo	# Med	# Hi	Max. Range	Min. Range	# Lo	# Med	# Hi	Max. Range
TS	36%	3.0%	1.0	40%	53%	7%	2.8	2.8	33%	40%	27%	3.2	3.2	27%	27%	46%	4.0

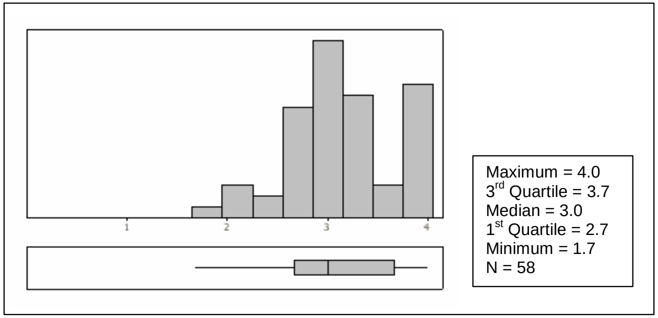
Survey Questions (Part 1)

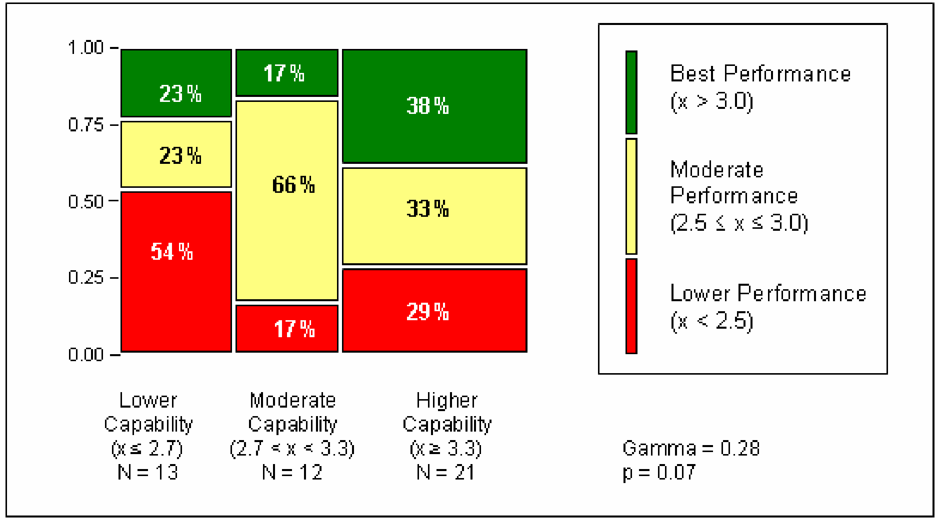
ID	Question	Response Range
RD11	Stakeholders impacted by trade studies are involved in the development and performance of those trade studies	•strongly disagree •disagree •agree •strongly agree
RD12	This project performs and documents trade studies between alternate solutions based upon definitive and documented selection criteria	•strongly disagree •disagree •agree •strongly agree
RD13	Documentation of trade studies is maintained in a defined repository and is accessible to all relevant project staff	•strongly disagree •disagree •agree •strongly agree
IF01	This project maintains accurate and up-to-date descriptions (e.g. interface control documents, models, etc.) defining interfaces in detail	•strongly disagree •disagree •agree •strongly agree
IF02	Interface definition descriptions are maintained in a designated location, under configuration management, and accessible to all who need them	•strongly disagree •disagree •agree •strongly agree

Survey Questions (Part 2)

ID	Question	Response Range
IF03a	For this project, the product high-level structure is documented, kept up to date, and managed under configuration control	•strongly disagree •disagree •agree •strongly agree
IF03b	For this project, the product high-level structure is documented using multiple views (e.g. functional views, module views, etc.)	•strongly disagree •disagree •agree •strongly agree
IF03c	For this project, the product high-level structure is accessible to all relevant project personnel	•strongly disagree •disagree •agree •strongly agree
IF04	This project has defined and documented guidelines for choosing COTS product components	•strongly disagree •disagree •agree •strongly agree

SE Capability:
Validation (VAL)





Relationship to project performance:	Moderately strong positive relationship

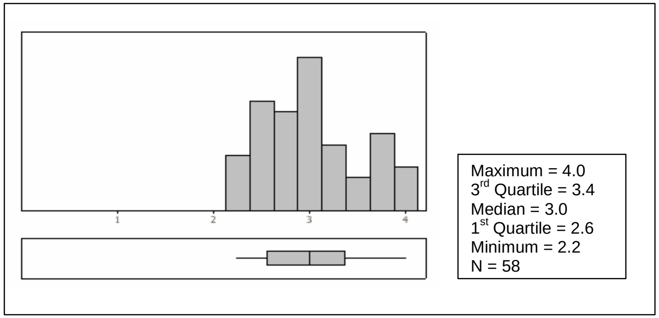
SE Capability

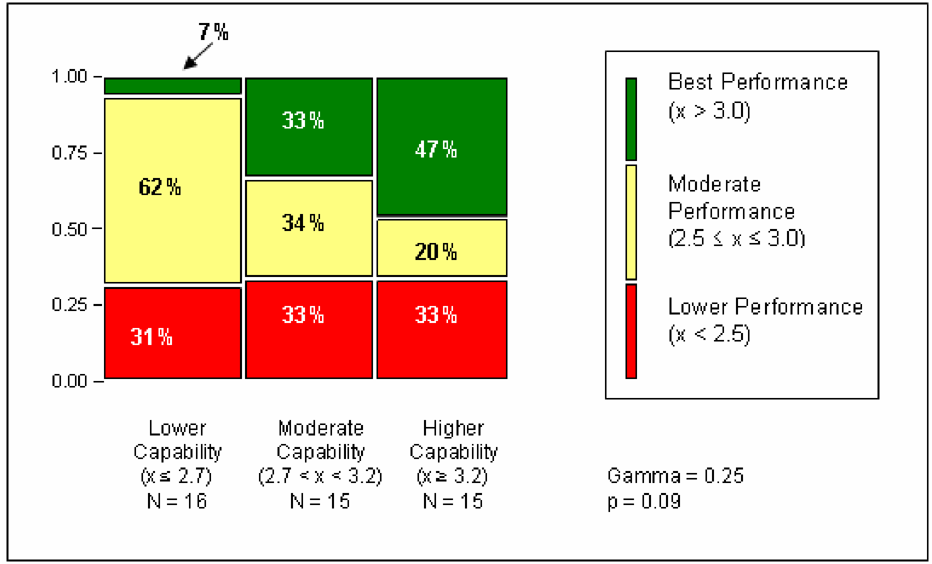
			Lower					Moderate					Higher				
	Gamma	p	Min. Range	# Lo	# Med	# Hi	Max. Range	Min. Range	# Lo	# Med	# Hi	Max. Range	Min. Range	# Lo	# Med	# Hi	Max. Range
VAL	28%	7.0%	1.0	54%	23%	23%	2.7	2.7	17%	66%	17%	3.3	3.3	29%	33%	38%	4.0

Survey Questions

ID	Question	Response Rate
V&V04a	This project has accurate and up-to-date documents defining the procedures used for the validation of systems and system elements	•strongly disagree •disagree •agree •strongly agree
V&V04b	This project has accurate and up-to-date documents defining acceptance criteria used for the validation of systems and system elements	•strongly disagree •disagree •agree •strongly agree
V&V05	This project maintains a listing of items managed under configuration control	•strongly disagree •disagree •agree •strongly agree

SE Capability: Verification (VER)





Relationship to project performance:	Moderately strong positive relationship

SE Capability

	Gamma	p	Lower: Min. Range	Lower: # Lo	Lower: # Med	Lower: # Hi	Lower: Max. Range	Moderate: Min. Range	Moderate: # Lo	Moderate: # Med	Moderate: # Hi	Moderate: Max. Range	Higher: Min. Range	Higher: # Lo	Higher: # Med	Higher: # Hi	Higher: Max. Range
VER	25%	9.0%	1.0	31%	62%	7%	2.7	2.7	33%	34%	33%	3.2	3.2	33%	20%	47%	4.0

Survey Questions (Part 1)

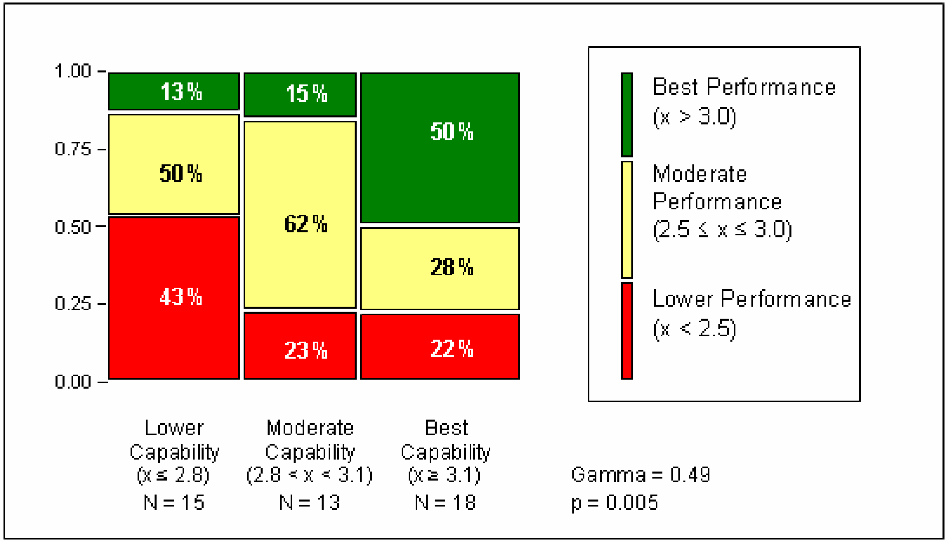
ID	Question	Response range
V&V01a	This project has accurate and up-to-date documents defining the procedures used for the test and verification of systems and system elements	•strongly disagree •disagree •agree •strongly agree
V&V01b	This project has accurate and up-to-date documents defining acceptance criteria used for the verification of systems and system elements	•strongly disagree •disagree •agree •strongly agree
V&V02a	This project has a documented and practiced review (e.g. peer reviews, design reviews, etc.) process that defines entry and exit criteria for work products	•strongly disagree •disagree •agree •strongly agree
V&V02b	This project has a documented and practiced review (e.g. peer reviews, design reviews, etc.) process that includes training requirements for the reviewers	•strongly disagree •disagree •agree •strongly agree
V&V02e	This project has a documented and practiced review (e.g. peer reviews, design reviews, etc.) process that addresses identified risks and risk mitigation activities during reviews	•strongly disagree •disagree •agree •strongly agree
V&V02f	This project has a documented and practiced review (e.g. peer reviews, design reviews, etc.) process that examines completeness of configuration baselines	•strongly disagree •disagree •agree •strongly agree

Survey Questions (Part 2)

ID	Question	Response range
V&V03	This project conducts non-advocate reviews (e.g. reviews by qualified personnel with no connection to or stake in the project) and documents results, issues, action items, risks, and risk mitigations	•strongly disagree •disagree •agree •strongly agree
V&V02c	This project has a documented and practiced review (e.g. peer reviews, design reviews, etc.) process that defines criteria for the selection of work products (e.g., requirements documents, test plans, system design documents, etc.) for review	•strongly disagree •disagree •agree •strongly agree
V&V02d	This project has a documented and practiced review (e.g. peer reviews, design reviews, etc.) process that tracks action items to closure	•strongly disagree •disagree •agree •strongly agree

SE Capability:
Combined Reqts+Tech Solution (REQ+TS)

(This is a higher order measure; see base measures for distribution)

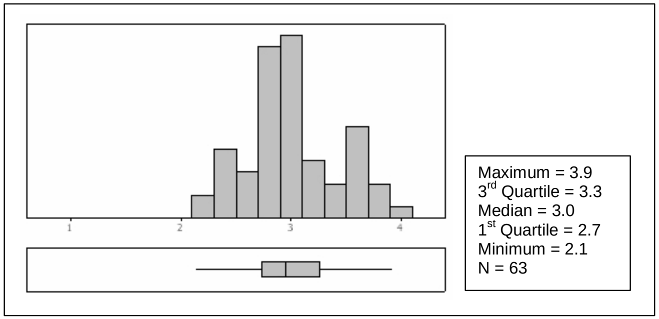


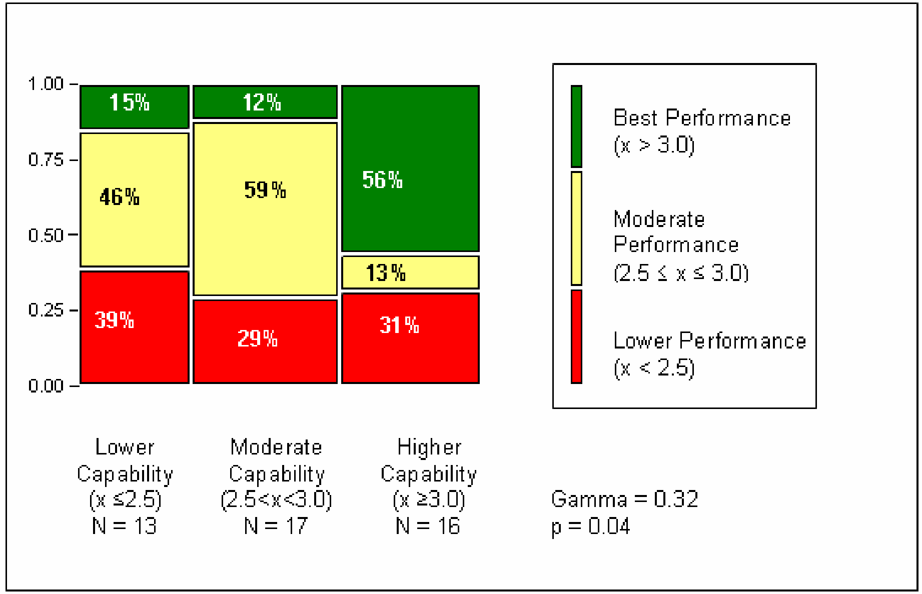
Relationship to project performance:	Strong positive relationship

SE Capability

	Gamma	p	Lower Min. Range	Lower # Lo	Lower # Med	Lower # Hi	Lower Max. Range	Moderate Min. Range	Moderate # Lo	Moderate # Med	Moderate # Hi	Moderate Max. Range	Higher Min. Range	Higher # Lo	Higher # Med	Higher # Hi	Higher Max. Range
REQ+TS	49%	0.5%	1.0	43%	50%	13%	2.8	2.8	23%	62%	15%	3.1	3.1	22%	28%	50%	4.0

SE Capability:
Total Systems Engineering Capability





Relationship to project performance:	Moderately strong positive relationship

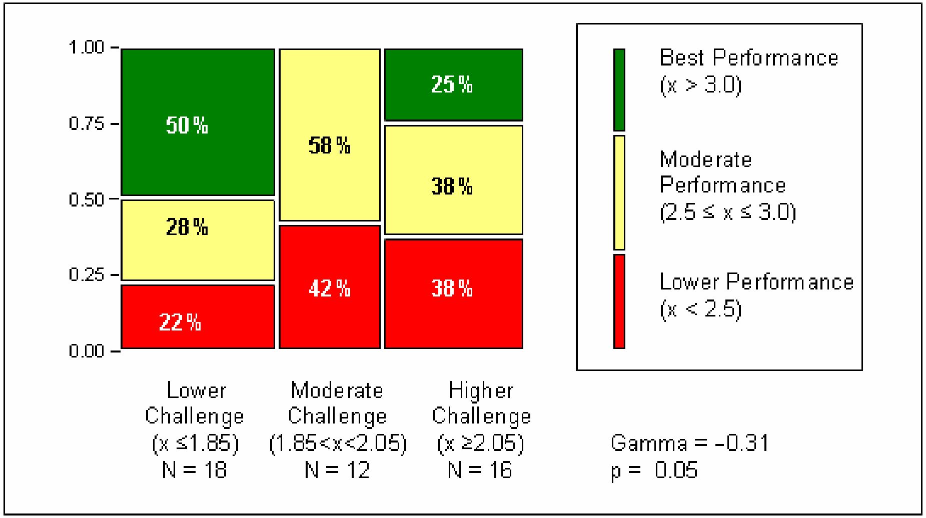
SE Capability

	Gamma	p	Lower Min. Range	Lower # Lo	Lower # Med	Lower # Hi	Lower Max. Range	Moderate Min. Range	Moderate # Lo	Moderate # Med	Moderate # Hi	Moderate Max. Range	Higher Min. Range	Higher # Lo	Higher # Med	Higher # Hi	Higher Max. Range
Overall SEC	32%	4.0%	1.0	39%	46%	15%	2.5	2.5	29%	59%	12%	3.0	3.0	31%	13%	56%	4.0

Project Challenge (PC)

Project challenge factors:

- Life cycle phases
- Project characteristics
  (e.g., size, effort, duration, volatility)
- Technical complexity
- Teaming relationships

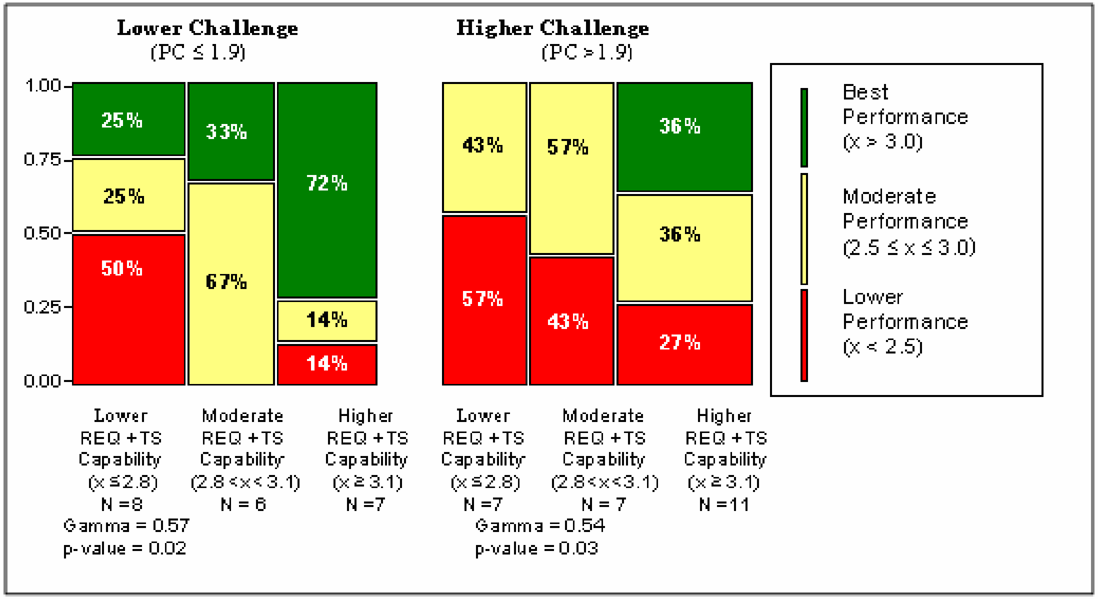


Relationship to project performance:	Moderately strong negative relationship

Project Challenge

			Lower					Moderate					Higher				
	Gamma	p	Min. Range	# Lo	# Med	# Hi	Max. Range	Min. Range	# Lo	# Med	# Hi	Max. Range	Min. Range	# Lo	# Med	# Hi	Max. Range
PC	-31%	5.0%	1.0	22%	28%	50%	1.85	1.85	42%	58%	0%	2.05	2.05	38%	38%	25%	4.0

SE Capability:
Reqts+Tech Solution with Project Challenge

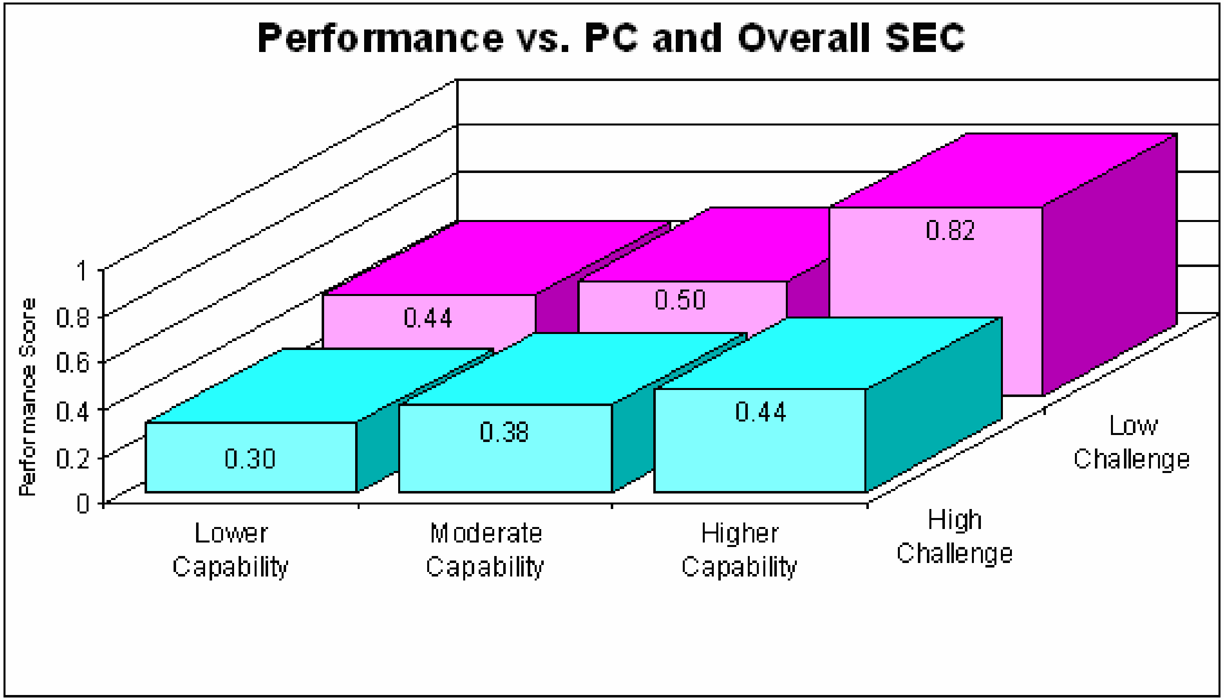


Relationship to project performance:	Very strong positive relationship

SE Capability + Project Challenge

	Gamma	p	Lower: Min. Range	Lower: # Lo	Lower: # Med	Lower: # Hi	Lower: Max. Range	Moderate: Min. Range	Moderate: # Lo	Moderate: # Med	Moderate: # Hi	Moderate: Max. Range	Higher: Min. Range	Higher: # Lo	Higher: # Med	Higher: # Hi	Higher: Max. Range
REQ+TS+PC	63%	0.0%	1.0	67%	33%	0%	1.7	1.7	25%	45%	30%	2.3	2.3	14%	36%	50%	4.0

Relating Project Performance to Project Challenge and SE Capability



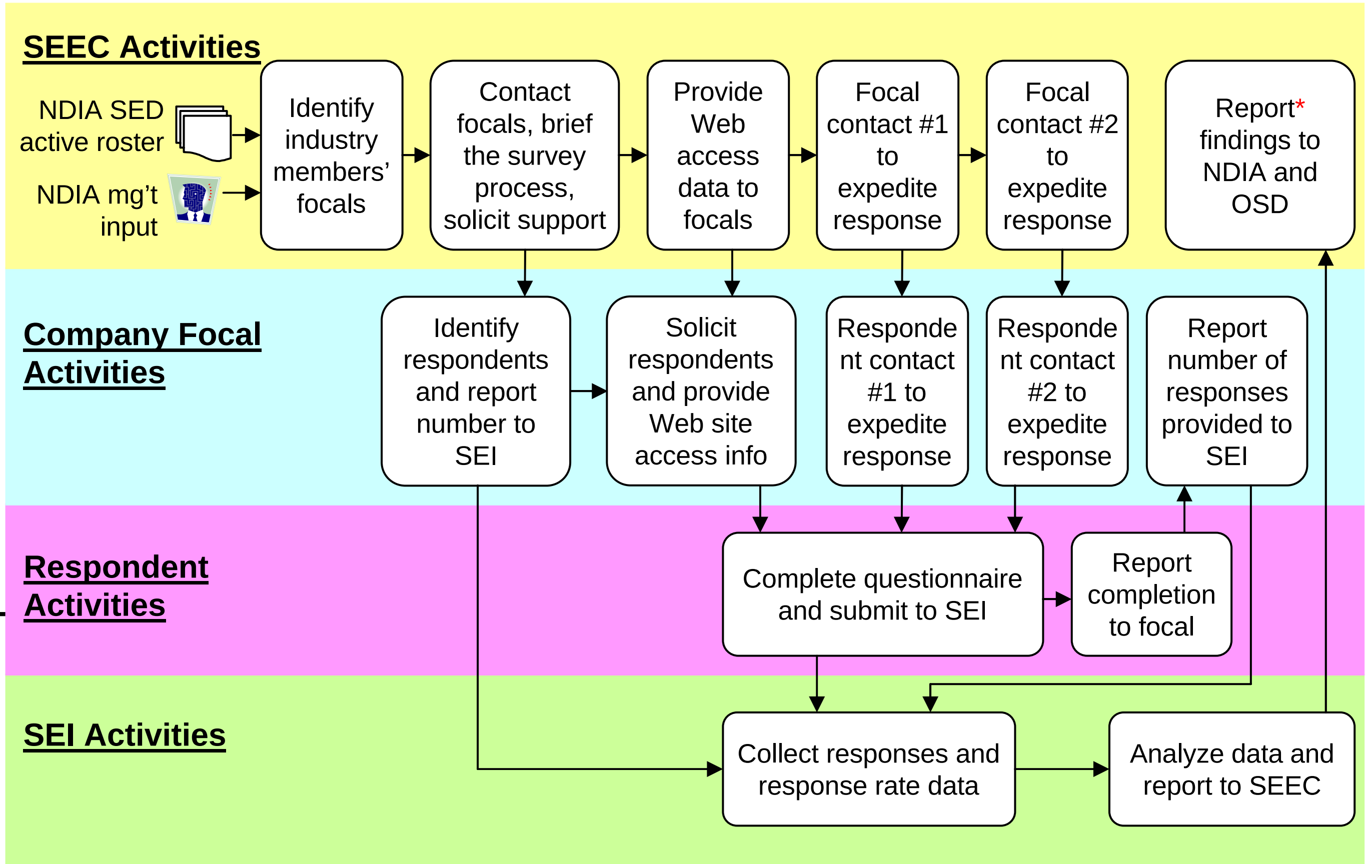
SE Effectiveness

Relationship of SEC to Performance

Supplier Systems Engineering Capability[1]	Relationship to Project Performance	Relationship (Gamma[2])	Section Reference
Project Planning	Weak positive relationship	+0.13	5.1.3.2
Project Monitoring and Control	Weak negative relationship	-0.13	5.1.3.3
Risk Management	Moderately strong positive relationship	+0.28	5.1.3.4
Requirements Development & Management	Moderately strong positive relationship	+0.33	5.1.3.5
Trade Studies	Strong positive relationship	+0.37	5.1.3.6
Product Architecture	Moderately strong to strong positive relationship	+0.40	5.1.3.7
Technical Solution	Moderately strong positive relationship	+0.36	5.1.3.8
Product Integration	Weak positive relationship	+0.21	5.1.3.9
Verification	Moderately strong positive relationship	+0.25	5.1.3.10
Validation	Moderately strong positive relationship	+0.28	5.1.3.11
Configuration Management	Weak positive correlation	+0.13	5.1.3.12
IPT-Related Capability	Moderately strong positive correlation	+0.34	5.1.3.1

SE Effectiveness

Methodology (In Detail)



$$\boldsymbol{Perf} = f\,(\boldsymbol{PC}, \boldsymbol{PE}, \boldsymbol{SEC}, \boldsymbol{AC})$$

***Perf* -** Project Performance
PC - Project Challenge
PE - Project Environment ***PE***
SEC - Systems Engineering Capability
AC - Acquirer Capability

Results

Summary of Relationships

Driving Factor	Relationship to Project Performance	
	Description	Γ
Requirements and Technical Solution Combined with Project Challenge	Very strong positive	+0.63
Combined Requirements and Technical Solution	Strong positive	+0.49
Product Architecture	Moderately strong to strong positive	+0.40
Trade Studies	Moderately strong to strong positive	+0.37
IPT-Related Capability	Moderately strong positive	+0.34
Technical Solution	Moderately strong positive	+0.36
Requirements Development and Management	Moderately strong positive	+0.33

Driving Factor	Relationship to Project Performance	
	Description	Γ
Total Systems Engineering Capability	Moderately strong positive	+0.32
Project Challenge	Moderately strong negative	-0.31
Validation	Moderately strong positive	+0.28
Risk Management	Moderately strong positive	+0.28
Verification	Moderately strong positive	+0.25
Product Integration	Weak positive	+0.21
Project Planning	Weak positive	+0.13
Configuration Management	Weak positive	+0.13
Process Improvement	Weak positive	+0.05
Project Monitoring and Control	Weak negative	-0.13

Real-Time Diagnostics for High Availability Systems

Edward Beck
Computer Sciences Corporation

NDIA Systems Engineering Conference
October 22-26, 2007

EXPERIENCE. RESULTS.

Agenda

- Background
- System Management Overview
- Case Study: Insight
- The Benefits of Insight

The Aegis Weapons System

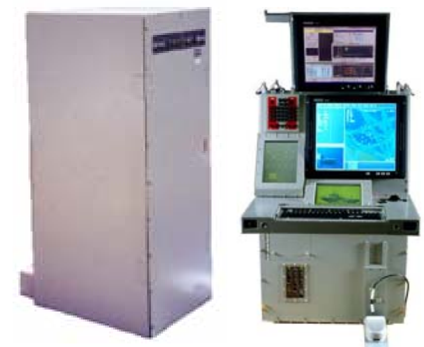
- Aegis is the world's premier naval surface defense system. It is capable of simultaneous operation defending against air, surface, subsurface and ballistic missile threats.
- There have been 7 major releases, known as baselines, in the nearly 4 decade history of Aegis.
- Recent baselines have focused on re-engineering the weapons system to take advantage of commercially available off-the-shelf (COTS) operating environments (OE).

A Migration to Open Architecture

Proprietary Systems

Manufactured hardware and developed software

Open Technology

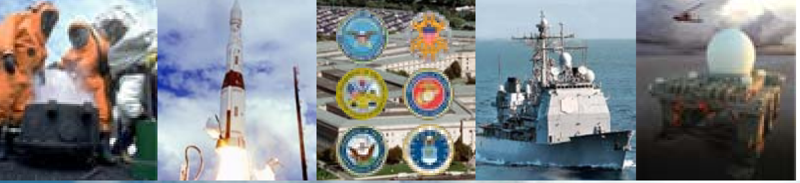


Emphasis on COTS hardware and software integration

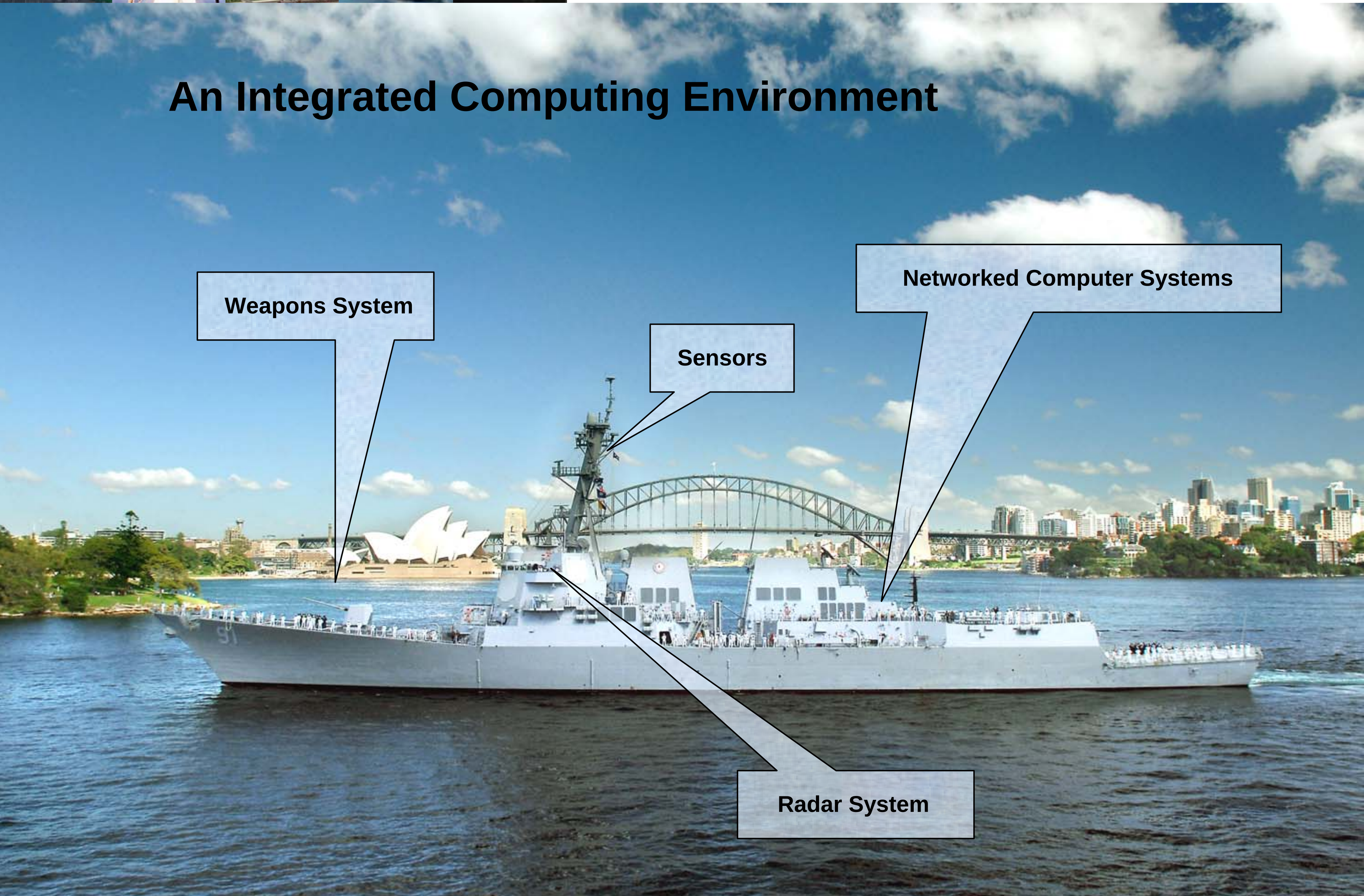
Computing System Management functions have become more complex with the adoption of COTS technology

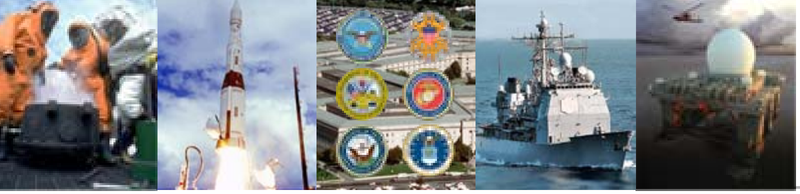
Open Technology

- An Aegis ship not much different from a large-scale commercial data center.
- The weapons system is comprised of a standard operating environment with unique components not seen in commercial architectures.



An Integrated Computing Environment





Air,
Missile &
National
Defense

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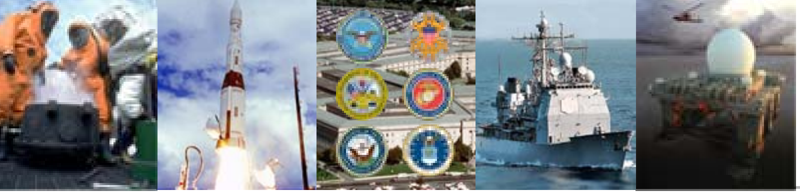
System Management Overview



Application Management

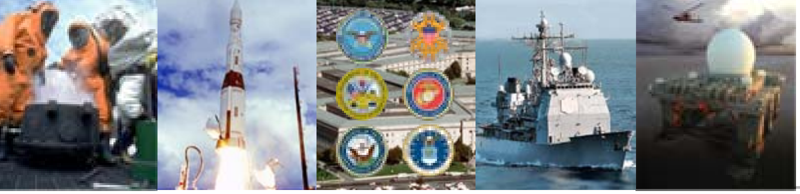
- Manage where applications are running
- Manage runtime state of the applications
- Manage recovery and reconfiguration
- Assess health status of the applications

Equipment Management

- Node/Server Management
  - **Diagnostics**
  - **Performance Monitoring**
- Network Management
- Asset Management
  - **Validation and Verification**
  - **Software Distribution**

Fault Detection / Fault Isolation

Root Cause Analysis



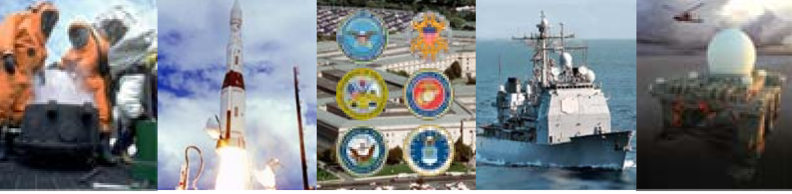
Aegis System Management

- In the current baselines, System Management for the Aegis Weapons System is comprised of multiple components.

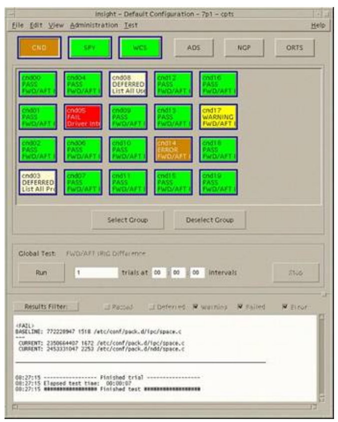
- Each component exists as a standalone entity.

- Together, they interoperate to provide an end-to-end solution for Operational Readiness Assessment of the combat system.

Insight is a key component for managing the operating environment of the Aegis Weapons System



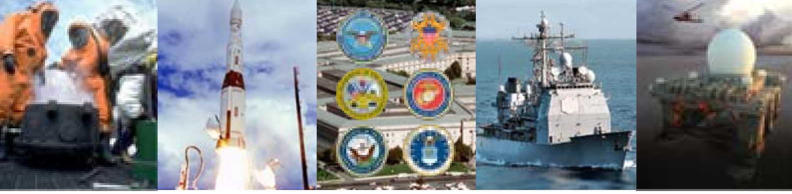
Case Study: Insight



What is Insight?

- An integrated computing system management toolkit.

- It is a highly configurable suite of open source, commercially available, and developed tools that perform system management functions across the enterprise.
  - Hardware and software diagnostics
  - Performance monitoring
  - Network management
  - System control
  - Validation and verification



The Catalyst For Insight

1994
Baseline 6 signals the emergence of COTS processors to augment the legacy computer suite.

2000
Deployment of Baseline 6 is plagued by schedule delays. Ad-hoc tools with weak fault detection and inefficient fault isolation.

2002
Initial version of Insight deployed to local data centers.

1970 - 1990   1995   2000   2001   2002   2003   2005

1969
Aegis begins. Baselines 1 through 5 are deployed with a proprietary operating environment.

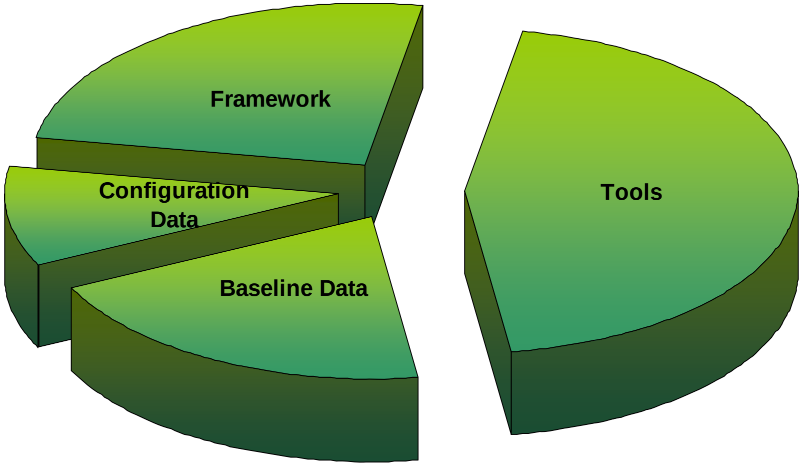
1999
Baseline 7 signals the emergence of an all-COTS computer suite.

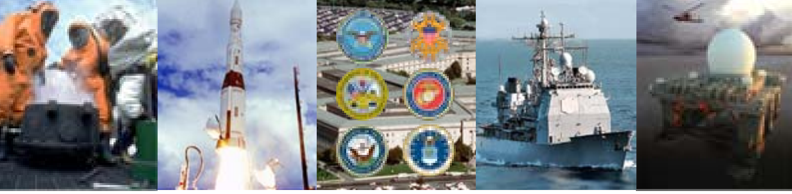
2001
CSC produced a White Paper to address the need for a well defined system management strategy on the COTS baselines. Design and development of Insight begins.

2003 - Current
Insight is deployed to Baseline 7 for use in shipyard integration activities and shipboard Operational Readiness Assessment.

Insight Component Architecture

- Framework
  – Graphical User Interface, Network Services, and Remote Agents
- Tools
  – Configurable collection of “best-of-breed” products and utilities to perform system management functions
- Configuration Data
  – Easily tailors Insight to the needs of the open architecture enterprise being managed
- Baseline Data
  – Repository of expected OE configuration state information

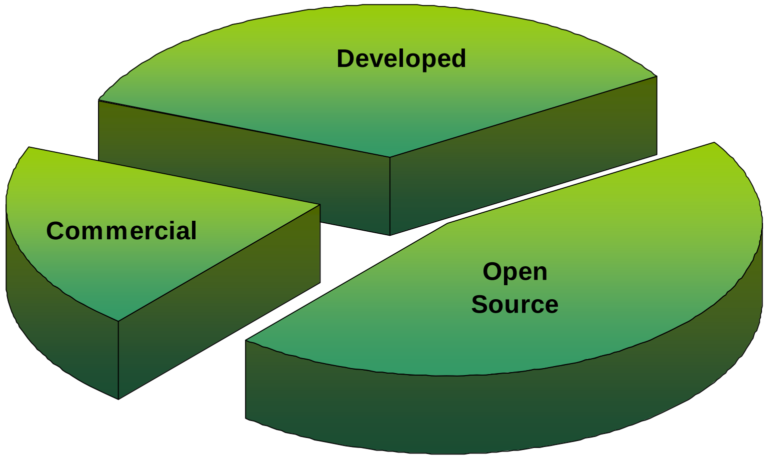




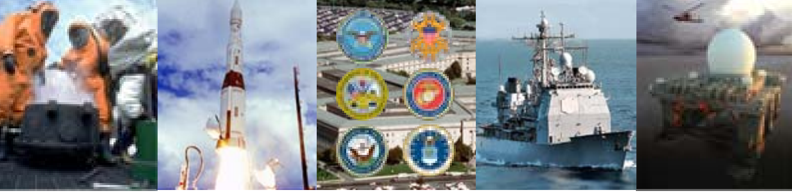
Extensive Use Of Open Source Technology

- Over 40% of Insight is comprised of Open Source software
  - Permits selection of cost effective, best-of-breed solutions
  - Reduces development time
  - Leverages intellectual resources from the world wide development community

Functional Composition



Capitalizing on Open Source saved approximately $1M in development costs



Application Management

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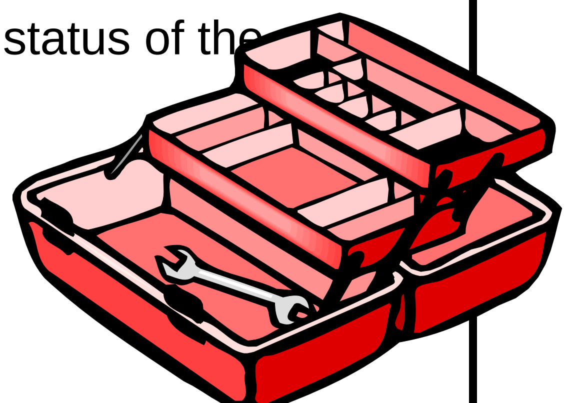
- Manage runtime state of the applications
- Manage recovery and reconfiguration
- Assess health status of the applications



Insight’s Toolkit

Equipment Management

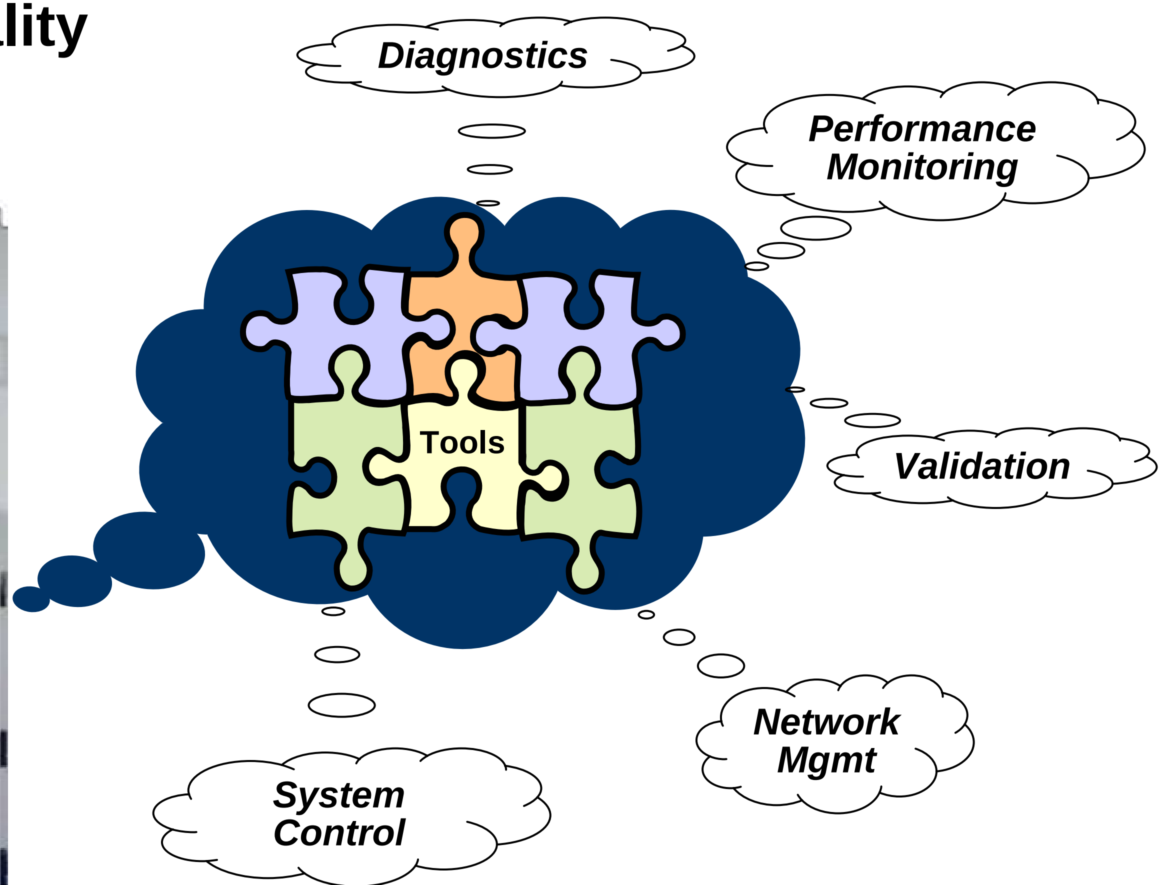
- Node/Server Management
  - **Diagnostics**
  - **Performance Monitoring**
- Network Management
- Asset Management
  - **Validation and Verification**
  - **Software Distribution**

Fault Detection / Fault Isolation

Root Cause Analysis

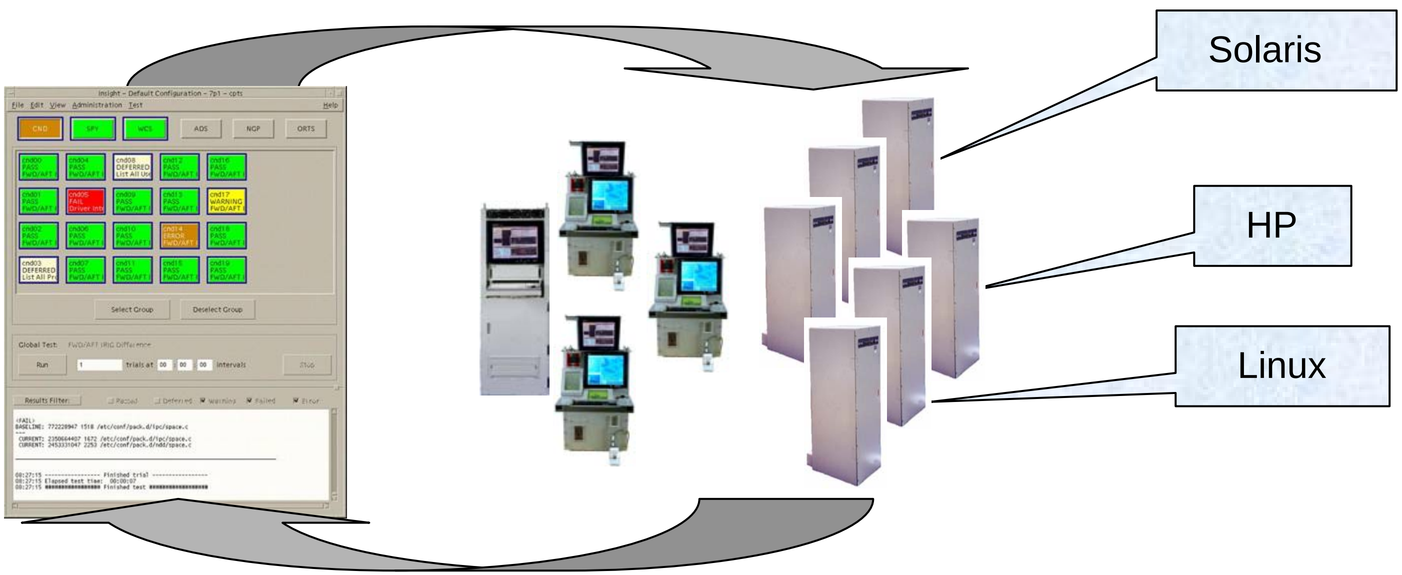
Insight Functionality

- On-demand Testing
- Runtime Monitoring
- Interactive Control

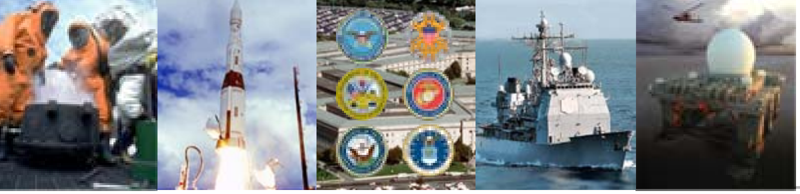


Consistent Interface for Disparate Tools

- Standardizes test execution
- Hides tool variability from the user
- Provides common results



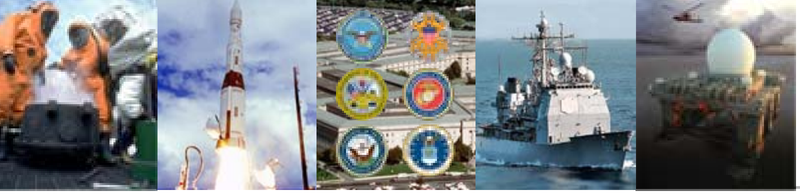
Insight standardizes the execution and results of each tool, regardless of platform or tool origin



Hardware and Software Diagnostics

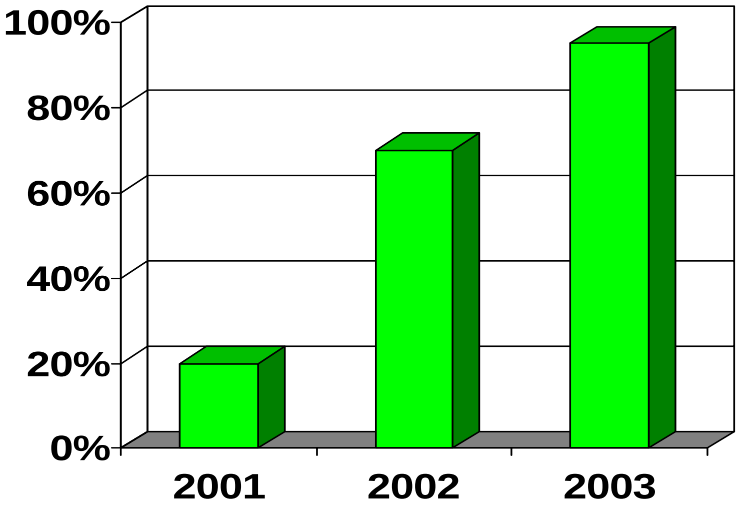
- Fault Detection / Fault Isolation (FD/FI)

- Assess the operational state of hardware and software components
  - NTDS Devices
  - I/O Boards
  - Specialized Processors
  - Tactical Interfaces
  - Middleware Components

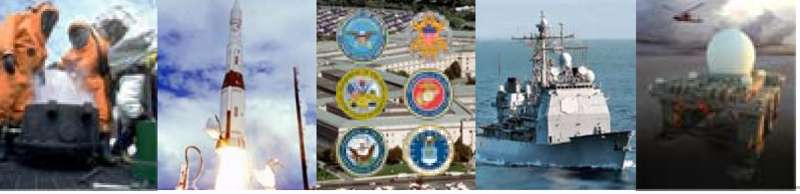


Increased Productivity

The availability of Insight has increased the productivity rate to over 90% by providing rapid identification of operating environment issues.



Rapid Resolution = Increased Productivity = Significant Savings

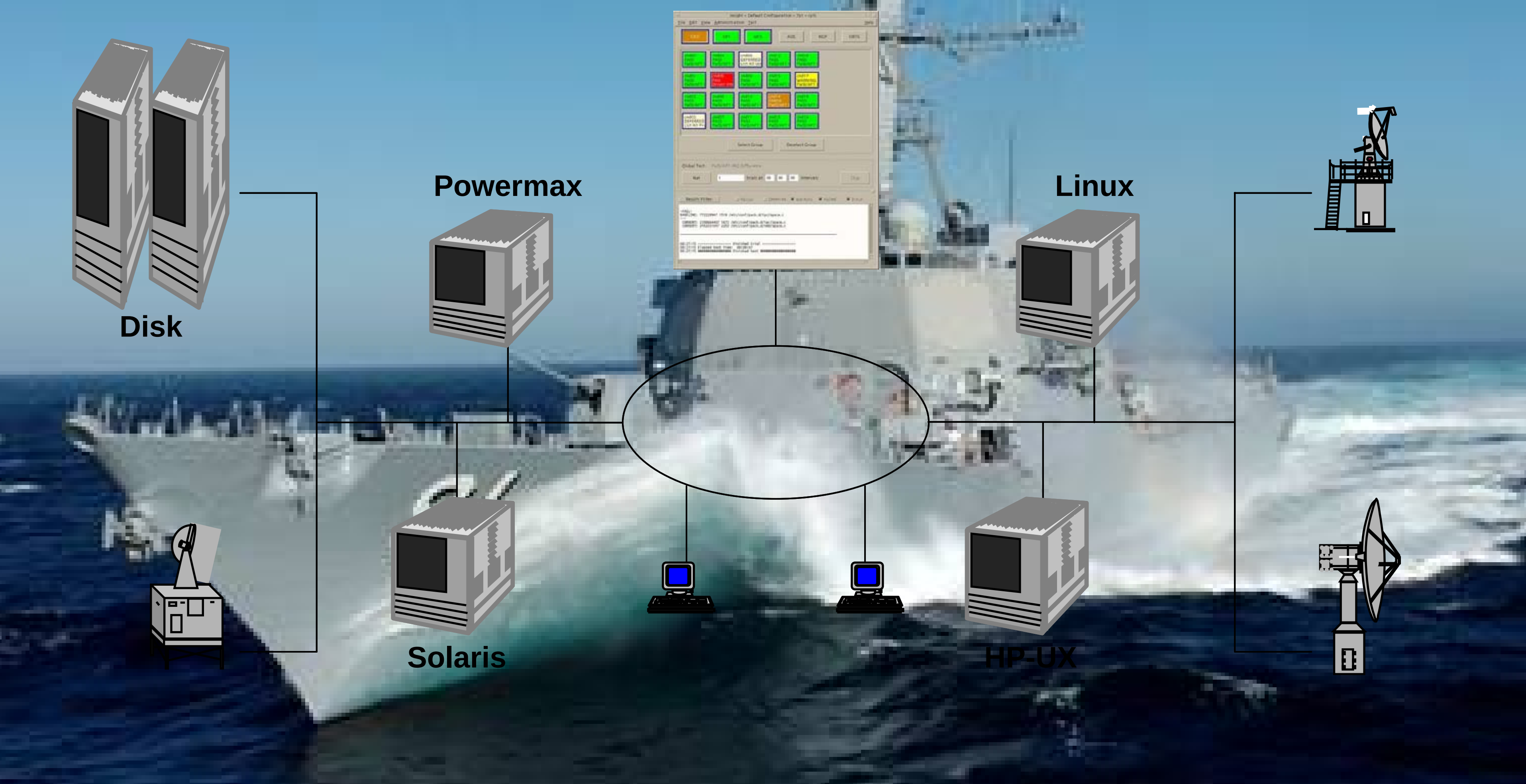


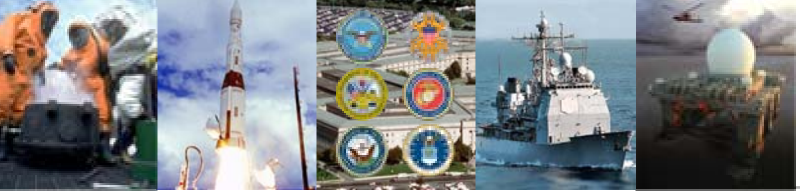
Performance Monitoring

- Assess infrastructure performance under operational conditions
  - CPU utilization
  - Memory utilization
  - Process activities
  - Disk usage
  - I/O activity
  - Kernel-level trace

- Data is represented in real-time as well as archived for statistical representation

Insight assesses operational readiness of combat system components from a single console





Validation and Verification

- System Operability Test

- Checks a number of Operating Environment configuration parameters to determine overall system operability
  - Configured Devices
  - Filesystem Integrity
  - Kernel Tunables
  - Network Tunables
  - Installed Packages
  - OS Version and Patches
  - Firmware

- Ensures that the current state of a host’s OE is consistent with established baseline data

Automated Validation of the Operating Environment

Integration and Test Facility

=

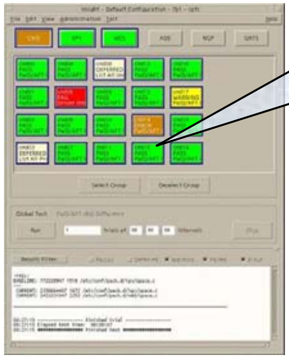
Deployed System

Insight ensures that the deployed configuration is identical to the staged environment

Automated System Validation: Months to Minutes

There are over 6000 configuration parameters on each node that are optimized for the application

Manual validation of the configuration for the entire computer suite would take nearly 4 staff months



Insight provides accurate validation for the entire computer suite within 3 minutes

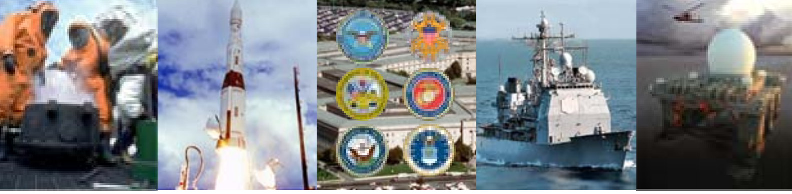
Automated validation provides complete confidence in the deployed configuration and saves significant taxpayer dollars

Network Management

- Assess health status and performance of the local area network
  - LAN operability
  - Routes
  - Network utilization

System Control

- Manage the run-time state of the tactical applications
  - System Initialization
  - Shutdown
  - Reboot



Run-time state of the system can be monitored and controlled from a single console

Concept of Operations

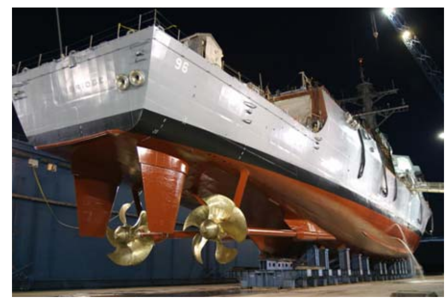
- Insight is used throughout the life-cycle of the combat system.

Development Data Center

Validation of the build environment

Staging and Test Facility

Shipyard Integration

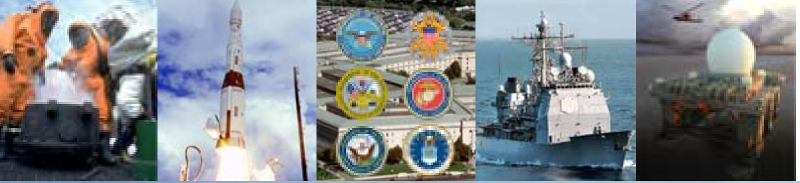


System validation, diagnostics, operability tests

Deployed Systems

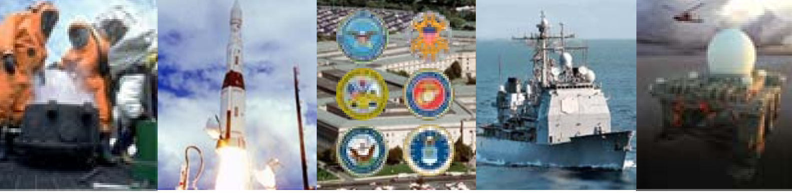
Runtime status monitoring, operability tests, diagnostics

Insight has become standard operating procedure for Aegis



Safety Checks

Insight’s safety agent prevents intrusive functions during tactical operations.



Air, Missile & National Defense

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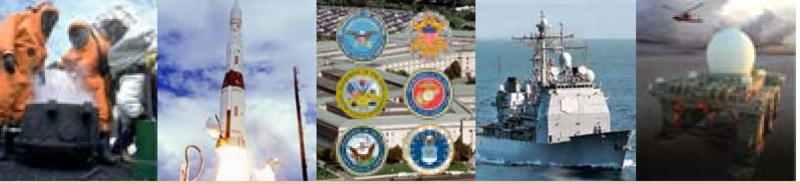
The Benefits of Insight

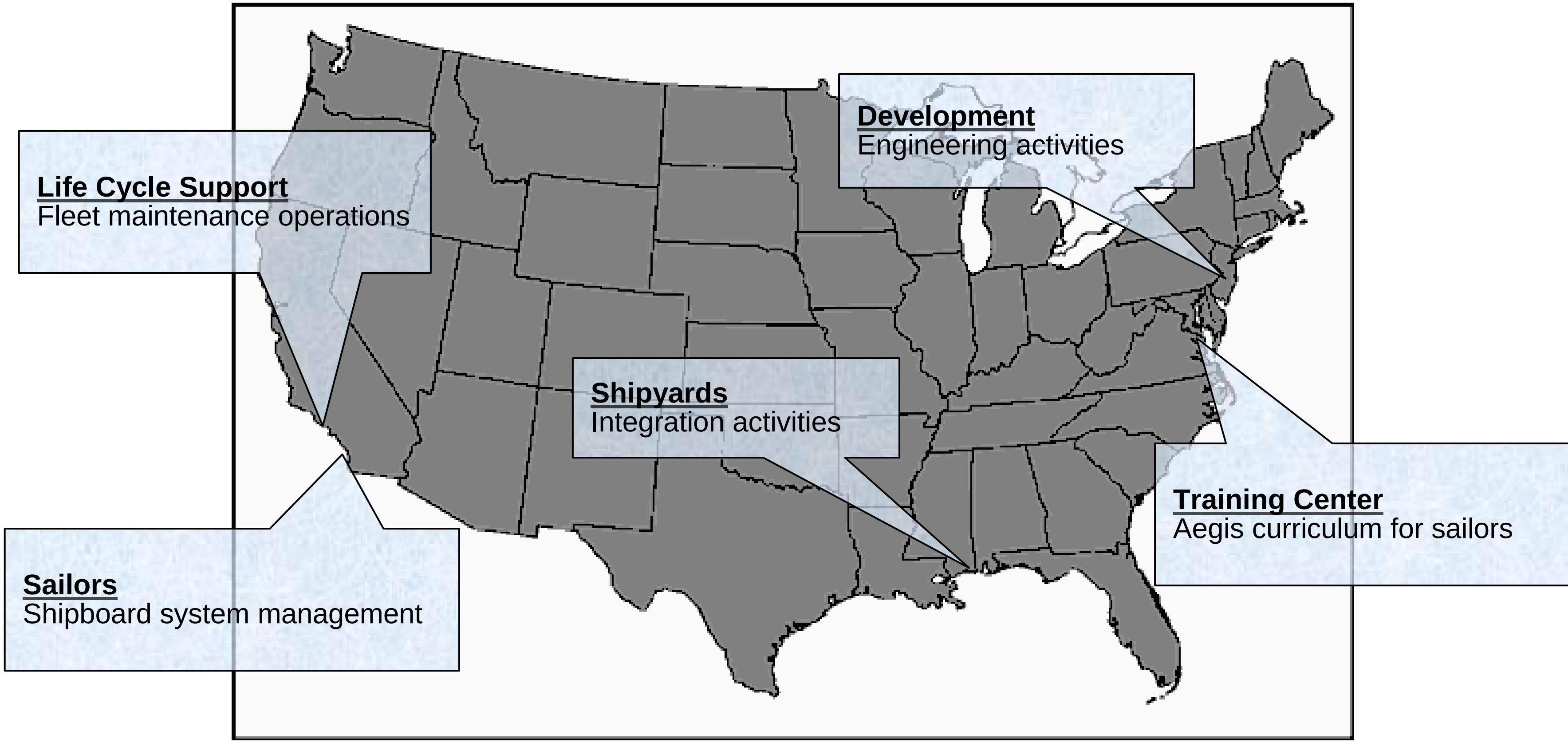


A Vital Maintenance Solution for the Aegis Weapons System

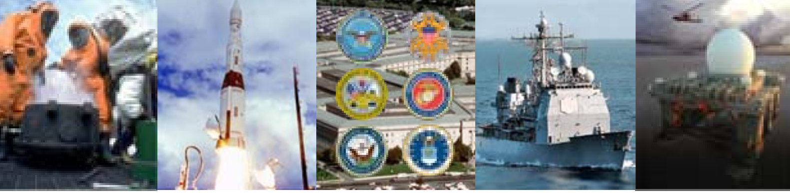
Proprietary systems had an available toolset.

Insight provides a robust toolset for COTS systems.

Applying Insight to Support Various Activities



Insight is a key component for Aegis System Management



Enhanced Operational Readiness

Dispatching engineers to troubleshoot shipboard issues:

$75K

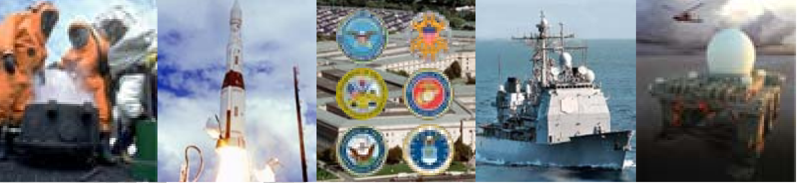
Delaying a missile test due to system instability:

$1M

Meeting deployment schedules and increasing credibility with your customer:

Priceless

Insight is playing a vital role ensuring that ships are deployed on schedule for immediate use in various theatres of operation



Air, Missile & National Defense

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“Innovation: Delivered”

- Deployed for 3 ½ years
- Multiple Baselines
- Domestic and Foreign Test Sites
- Domestic and Foreign War Ships
- Certified for Tactical Operations

Air, Missile & National Defense

CSC EXPERIENCE. RESULTS.

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Principal Computer Scientist
Operating Environment Support

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Update: OSD Systems Engineering Revitalization Efforts

23 October 2007

Col Rich Hoeferkamp

Ms. Sharon Vannucci

Systems and Software Engineering

(Enterprise Development)

Office of the Deputy Under Secretary of Defense (Acquisition & Technology)

General Outline

- What's happening in:
  - Policy
  - Education & Training
  - Guidance
- Other Initiatives
- Topics for Discussion

System Engineering Policies

All programs shall develop a SE Plan (SEP)

Each PEO shall have a lead or chief systems engineer who monitors SE implementation within program portfolio

Event-driven technical reviews with entry criteria and independent subject matter expert participation

OSD shall review program's SEP for major acquisition programs (ACAT ID and IAM)

Technical Planning

Technical Leadership

Technical Execution

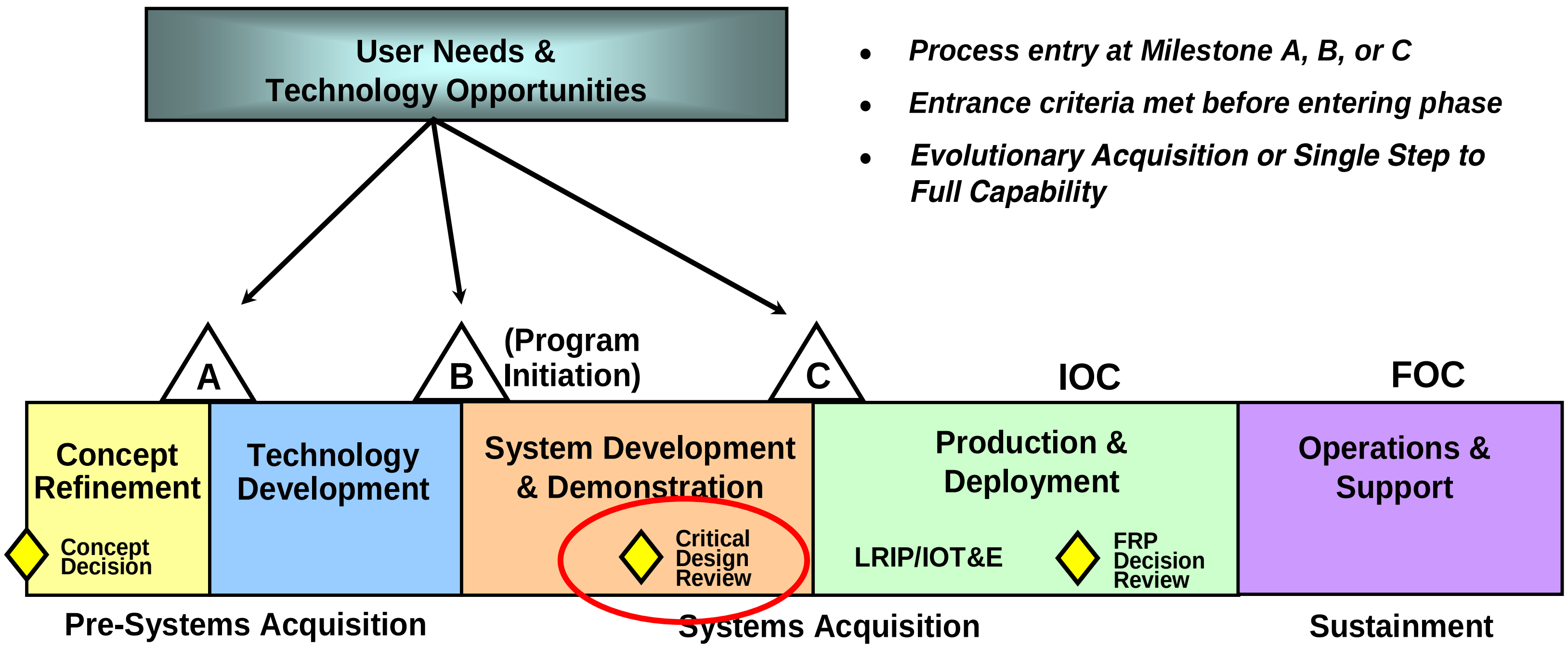
Technical Excellence

Technical planning upfront and early

New SE Policy in *Draft* DoDI 5000.2, Operation of the Defense Acquisition System

3.0 PROCEDURES

3.1. Defense Acquisition Management Framework. Figure 1 depicts the Defense Acquisition Management Framework.



- *Process entry at Milestone A, B, or C*
- *Entrance criteria met before entering phase*
- *Evolutionary Acquisition or Single Step to Full Capability*

New SE Policy in Draft DoDI 5000.2

- § 3.6.5. "systems engineering planning shall support" the Technology Development phase

- § 3.7.8. "System Design [first phase of SDD] shall include the establishment of the functional, allocated, and product baselines for all configuration items. The CDD [Capability Development Document] and Systems Engineering Plan [SEP] shall guide this effort."

- § 3.7.9. "Critical Design Review (CDR). The system-level CDR provides an opportunity to assess design maturity as evidenced by measures such as successful completion of subsystem CDRs; the percentage of hardware and software product build-to specifications and drawings completed and under configuration management; planned corrective actions to hardware/software deficiencies; adequate developmental testing; an assessment of environment, safety and occupational health risks; a completed failure modes and effects analysis; the identification of key system characteristics and critical manufacturing processes; and an estimate of system reliability based on demonstrated reliability rates, etc."

New SE Policy in Draft DoDI 5000.2

§ 3.7.9.1. "The PM shall provide a **CDR Report** to the MDA that provides an overall assessment of design maturity and a summary of the system-level CDR results which shall include, but not be limited to:

- § 3.7.9.1.1. The names, organizations, and areas of expertise of independent subject matter expert participants and CDR chair;
- § 3.7.9.1.2. A description of the product baseline for the system and the percentage of build-to packages completed for this baseline;
- § 3.7.9.1.3. A summary of the issues and actions identified at the review together with their closure plans;
- § 3.7.9.1.4. An assessment of risk by the participants against the exit criteria for the SDD phase; and
- § 3.7.9.1.5. Identification of those issues/risks that could result in a breach to the program baseline or substantively impact cost, schedule or performance."

§ 3.7.9.2. "The MDA shall review the CDR Report and the PM's resolution/ mitigation plans and determine whether additional action is necessary to satisfy SDD phase exit criteria and to achieve the program outcomes specified in the APB."

New SE Policy in Draft DoDI 5000.2

§ 3.10.6. "**Program Support Review** (PSR). The Office of the USD(AT&L)/ Systems and Software Engineering shall conduct PSRs for MDAPs to assess the application of technical planning and management processes and assist the program office in identifying and mitigating cost, schedule, and performance risk. PSRs shall be conducted prior to each milestone event, before approval of the SDD acquisition strategy, and at other times as directed by the USD(AT&L). The results of a PSR shall inform the OIPT and be provided to the MDA. PSRs on MAIS programs shall be conducted when requested by the MDA."

Enclosure 3. Table E3.T2: **SEP mandated at milestones A, B, and C**

Enclosure 5. § E5.7.2. "The Office of the USD(AT&L)/ Systems and Software Engineering shall conduct an independent **Assessment of Operational Test Readiness** (AOTR) for all ACAT ID and special interest programs designated by the USD(AT&L). Each AOTR shall consider the risks associated with the system's ability to meet operational suitability and effectiveness goals. This assessment shall be based on capabilities demonstrated in DT&E and OAs and criteria described in the TEMP. The AOTR report shall be provided to the USD(AT&L), DOT&E, and CAE."

§ E5.7.3. "The CAE shall consider the results of the AOTR prior to making a determination of materiel system readiness for IOT&E."

New SE Policy in Draft DoDI 5000.2

Enclosure 12. Systems Engineering.

E12.1. Systems Engineering Across the Acquisition Lifecycle.

E12.2. Systems Engineering Plan (SEP).

E12.2.1. "Program managers shall prepare a SEP for each milestone review, beginning with A."

E12.2.2. "The MDA shall be the approval authority for the SEP."

E12.3. Systems Engineering Leadership. Each Program Executive Officer shall have a lead or chief systems engineer on his or her staff responsible to the PEO for systems engineering across the PEO's portfolio of programs and shall:

E12.3.1. Review assigned programs' SEPs and oversee their implementation.

E12.3.2. Assess performance of subordinate lead or chief system engineers.

E12.4. Technical Reviews. Technical reviews shall be event driven, conducted when documented entrance criteria are met, and include participation by subject matter experts who are independent of the program.

E12.5. Configuration Management. Documented in the SEP, the configuration management approach shall identify, document, audit, and control the functional and physical characteristics of the system design, track any changes, and provide an audit trail of program design decisions and design modifications.

New SE Policy in Draft DoDI 5000.2

E12.6. <u>Environment, Safety, and Occupational Health (ESOH)</u>. The PM shall use the methodology in MIL-STD-882D to assess ESOH risk, eliminate ESOH hazards where possible, manage the risks that cannot be eliminated, and report on the status of ESOH risk at technical reviews.

E12.6.1. <u>Programmatic ESOH Evaluation (PESHE)</u>. The PM for all programs, regardless of ACAT level, shall prepare a PESHE and summarize it in the acquisition strategy.

E12.5.2. <u>NEPA/EO 12114</u>. The PM shall conduct and document NEPA/EO 12114 analyses, to be approved by the CAE, for which the PM is the action proponent.

E12.6.3. <u>Mishap Investigation Support</u>. The PM will support system-related Class A and B mishap investigations.

E12.7. <u>Corrosion Prevention and Control</u>. Each ACAT I program shall document its strategy in a Corrosion Prevention Control Plan at Milestones B and C.

E12.8. <u>Modular Open Systems Approach (MOSA)</u>. Program managers shall employ MOSA.

E12.9. <u>Data Management and Technical Data Rights</u>. Program managers for all ACAT I and II programs shall assess their long-term technical data needs and document them in a Data Management Strategy which shall be approved in the context of the acquisition strategy prior to issuing a contract solicitation.

Education & Training

➢ What's available

- On-line Continuous Learning Modules (CLMs):
  - Reliability and Maintainability
  - Technical Reviews
  - Technical Planning
  - MOSA (new)
  - Trade Studies (new)
- On-line introductory course SYS 101
- On-line intermediate course SYS 202
- Intermediate classroom course SYS 203
- Advanced classroom course SYS 302
- New "SPRDE/Program Systems Engineer" track
- "Core Plus" career guidance (new)

➢ What's Coming

- Data Management CLM
- ECP CLM

New SPRDE/PSE & SE Career Path Certification Criteria

SPRDE-Program Systems Engineer

LEVEL I (2 Years)

- ACQ 101
- SYS 101
- Two additional Level 100 courses from a variety of disciplines
- XXX 101
- AND
- XXX 101

LEVEL II (4 Years)

- ACQ 201A/B
- CLM 003
- SYS 202
- SYS 203
- LOG 204 (CM) + one additional Level 100 or 200 course from a variety of disciplines
- LOG 204 (now online)
- XXX 101
- OR
- XXX 201

LEVEL III (8 Years)

- CLL 008
- SYS 302
- Two additional Level 200 or 300 courses from a variety of disciplines
- XXX 201
- AND
- XXX 301

SPRDE-Systems Engineering

LEVEL I (1 Years)

- ACQ 101
- SYS 101

LEVEL II (2 Years)

- ACQ 201A
- ACQ 201B
- CLM 003
- SYS 202
- SYS 203

LEVEL III (4 Years)

- CLL 008
- SYS 302

Legend:

- Existing
- New
- Additional

Education & Training
New SPRDE Key Tenets

- *Personnel*: those currently certified SPRDE-SE retain their certification

- *Positions*: those currently coded as “S” (SPRDE-SE) retain that designation—subsequently, Components shall review positions to determine if they should remain coded as SPRDE-SE (“S”) or if they should be recoded as SPRDE-PSE (“Code TBD”)

Guidance

- What's available:
  - Systems Engineering Plan (SEP) Preparation Guide, V2 (just released)
  - Risk Management Guide for DoD Acquisition
  - DoD Guide for Achieving Reliability, Availability, and Maintainability
  - Integrated Master Plan/Integrated Master Schedule (IMP/IMS) Guide
  - Guide to Integrating SE into DoD Acquisition Contracts
  - Understanding and Leveraging a Supplier's CMMI Efforts: A Guidebook for Acquirers
  - Risk Assessment Technical Review Checklists (new)
- What's coming:
  - Systems of Systems SE Guide
  - Update to Defense Acquisition Guidebook
    - Chapter 4 -- Systems Engineering
    - Chapter 9 -- Test and Evaluation

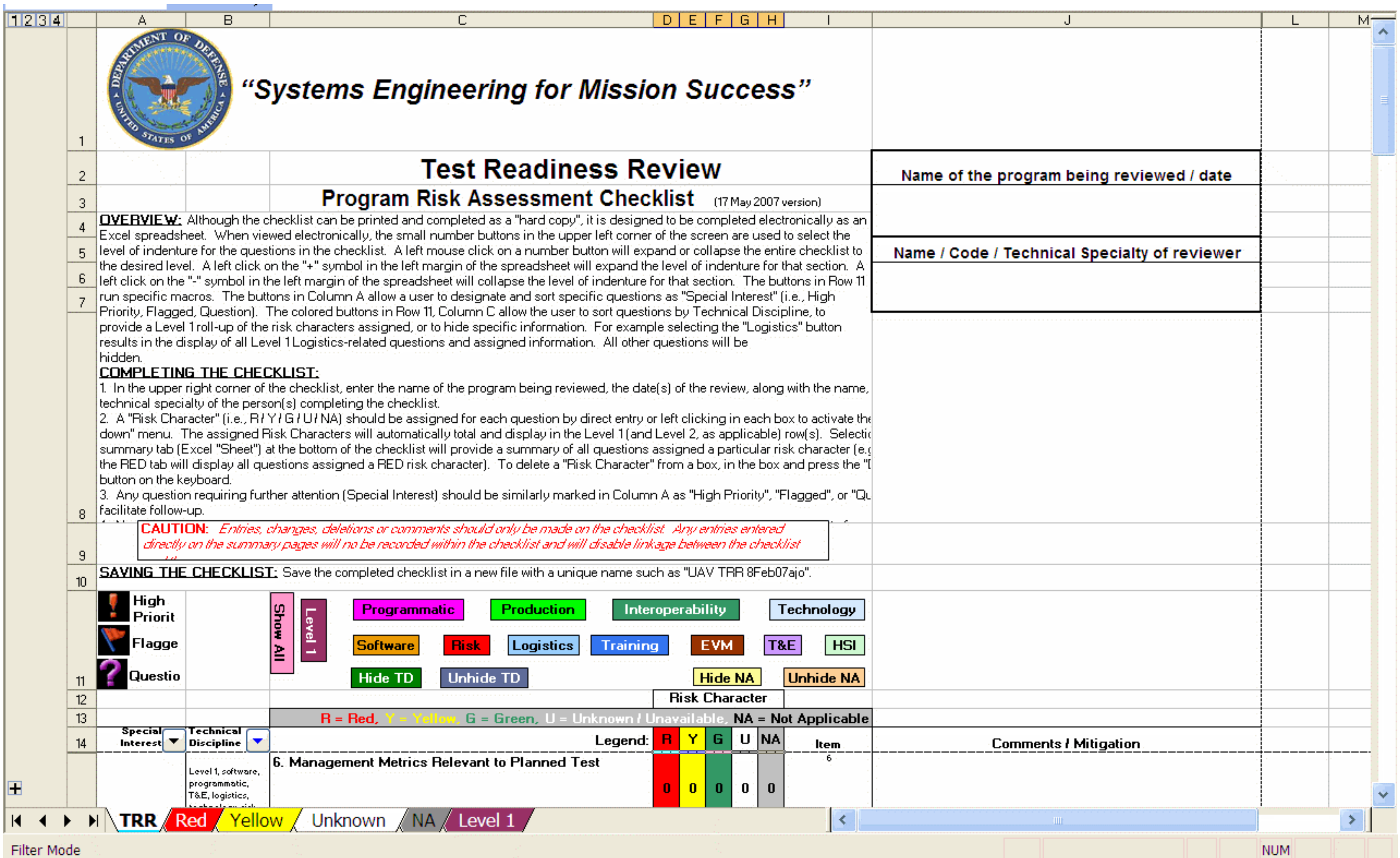
Updated SEP Prep Guide

- Includes sections by program phase:
  - MS A/Technology Development
  - MS B/System Development & Demonstration
  - MS C/Production & Deployment and Operations & Support
- Each section provides more "food for thought" relative to the technical planning focus areas for that phase
  - Program Requirements
  - Technical Staffing
  - Technical Baseline Management
  - Technical Review Planning
  - Integration with Overall Management of the Program

Vision: SE Plan Unification

- <u>Acquirer/Supplier-developed technical plan</u> for SE implementation
- Acquirer/Supplier <u>shared roles and responsibilities</u> in SE effort
- Acquirer/Supplier conducted <u>event driven technical reviews</u>
- Acquirer/Supplier <u>teaming on linkage with other program plans</u>

TRR Checklist



BACK

TRR Checklist

High Priorit | Flagge | Questio

Show All | Level 1

Programmatic | Production | Interoperability | Technology

Software | Risk | Logistics | Training | EVM | T&E | HSI

Hide TD | Unhide TD | Hide NA | Unhide NA

Risk Character

R = Red, Y = Yellow, G = Green, U = Unknown / Unavailable, NA = Not Applicable

Row	Special Interest	Technical Discipline	Legend:	R	Y	G	U	NA	Item	Comments / Mitigation
108		Level 1, software, programmatic, T&E, logistics, technology, risk,	**6. Management Metrics Relevant to Planned Test**	0	0	0	0	0	6	
123		Level 1, T&E, risk, programmatic	**7. Test Program Risk Assessment**	0	0	0	0	0	7	
124		programmatic, T&E, risk	a. Risk Impacts	0	0	0	0	0	7.a	
125		programmatic, T&E, risk	(1) Have all test related risks been identified, and are they being tracked on a continuous basis including updates to the mitigation approaches?						7.a(1)	
126		programmatic, T&E, risk	(2) Have all test related risks been determined to be of an acceptable level to enter testing?						7.a(2)	
127		programmatic, T&E, risk	b. Are mitigation approaches in place for all "yellow" and "red" test related risks, and are test risk mitigations resourced?						7.b	
128		programmatic, T&E, risk	c. Risk Process	0	0	0	0	0	7.c	
129		programmatic, T&E, risk	(1) Does the program have an overall Risk Management Plan (RMP)?						7.c(1)	
130		programmatic, T&E, risk	(2) Is there a defined program level risk management process, and is the RMP up to date and being used?						7.c(2)	
131		programmatic, T&E, risk	(3) Is the risk management process shared by the Government and contractor team?						7.c(3)	
		programmatic, T&E, risk	(4) Have all applicable test related risks for the system under test been included in the program level risk management process?						7.c(4)	

TRR | Red | Yellow | Unknown | NA | Level 1

Filter Mode NUM

Corrosion

- Overarching strategy: transcend traditional control methods, organizations, management and funding approaches
- Attack corrosion early in acquisition or construction
- Focus life-cycle corrosion research and development efforts on four primary areas
  - Materials and manufacturing processes that prevent or reduce the incidence and effects of corrosion
  - Detection of corrosion in fielded systems and facilities and prognosis of the expected growth, potential impact and predicted effects
  - Coatings, treatments and other applications to prevent, arrest or retard corrosion
  - Repair processes that restore materials to an acceptable level of structural integrity and functionality
- Publish direction and guidance regarding corrosion prevention and mitigation policies and strategies at all DoD and Service levels

SE Research

- Recognizes need to advance the practice of systems engineering within DoD
  - Conduct innovative research into new SE methods, processes, and tools (MPTs) to address recurring problems in the acquisition of systems and services.

- Currently investigating stand-up of an SE research University Affiliated Research Center (SER UARC) to help accomplish this

- SE UARC mission: to research and analyze advanced and emerging systems engineering practices and relevant technologies to address the full spectrum of DoD systems across the Department,
  - From capability areas, enterprise systems, systems of systems, and interoperability down to subsystems and configuration items
  - Goal is to ensure consistency and SE excellence throughout acquisition life cycle

- Bottom line:
  - We've made great strides, but much still to do to change root cause behaviors on programs.
  - SE research will:
    - Inform the current state of SE practice on programs
    - Provide a means to explore and exploit concepts to enable design and development of complex systems
    - Underpin effective integration of program/business processes with technical management MPTs throughout the acquisition life cycle.

Topics for Discussion

- What are your thoughts on:

  - The “help” you are getting from OSD (policy, guidance, Education & Training, Programs Support Reviews, SEP reviews, etc.)
    - Have the SE policy memos of 2004 caused you to do anything different?
  - What it takes to deploy effective SE across all programs
  - The availability of resources you have to put on SE, and ability to train them
  - The need for independent chair at technical reviews outside of the program
  - Mandating development of the SEP prior to RFP release
  - A unified acquirer/supplier SEP

Topics for Discussion

➢Other questions to consider:

- How are technical reviews conducted and when are they held? Are they schedule driven or event-based?
- Do you have “technical baselines”? What process do you use to track and manage them?
- Who does your planning (e.g. writes your SEP and Risk Plan)? Are these plans used and are they value added?
- How do the SEP, Risk Plan, TEMP and other technical documents integrate with the acquisition strategy?

Way ahead

Taking SE to the next level – Expand institutionalization…

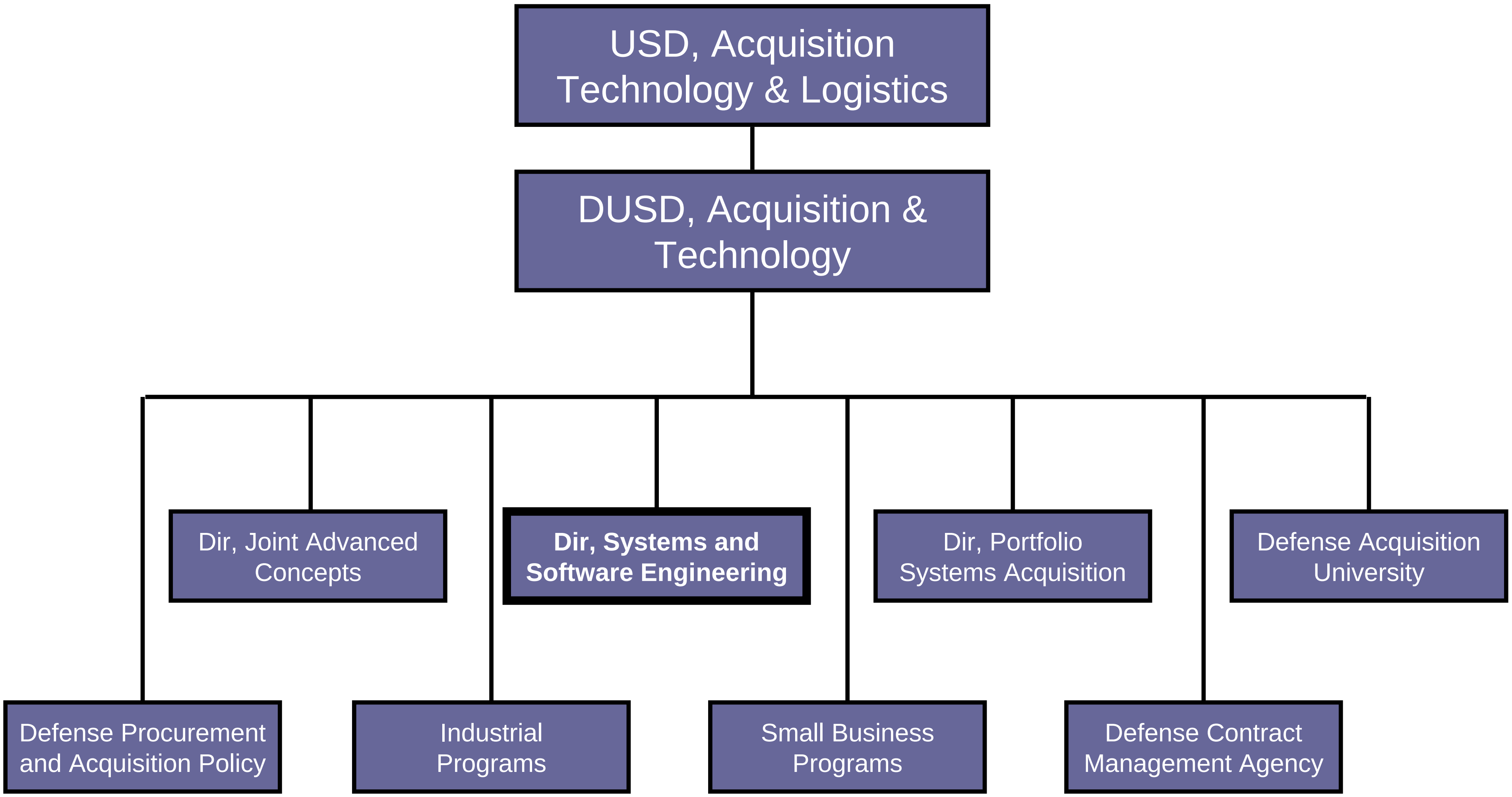
- Change culture, both vertically and horizontally, across Government and DoD contractor workforce
  - Expand outreach effort to the product centers, program offices, and key industry partners
  - Continue to leverage collaboration with DAU and academia to further develop the workforce

SE links

Systems and Software Engineering (updated website):
http://www.acq.osd.mil/sse

DAU:
http:www.dau.mil/basedocs/trainingcourses.asp

OUSD (AT&L) Organization



Systems and Software Engineering
Organizational Core Competencies

Director, Systems & Software Engineering
Mark Schaeffer SES

Deputy Director Enterprise Development
Col Rich Hoeferkamp (Acting)

CORE COMPETENCIES

- SE Policy
- SE Guidance
  - SE in *Defense Acquisition Guidebook*
  - Technical Planning
  - Risk Management
  - Reliability/Maintainability
  - Integrating SE into Systems Acq contracting
  - SoS SE Guide
- SE Education and Training
  - DAU SE Curriculum
  - SPRDE Certification Rqmt
- Corrosion
- R-TOC
- Value Engineering

Deputy Director Developmental Test & Evaluation
Chris DiPetto SES

CORE COMPETENCIES

- DT&E Policy
- DT&E Guidance
  - T&E in *Defense Acquisition Guidebook*
  - TEMP Development Process
- DT&E Education and Training
  - DAU DT&E Curriculum
  - DT&E Certification Rqmt
- Joint Testing, Capabilities & Infrastructure
- Targets Oversight
- Acq Modeling & Simulation
- Energy
- DSOC/Acq Tech Task Force

Deputy Director Software Engineering & System Assurance
Kristen Baldwin SES

CORE COMPETENCIES

- SWE and SA Policy
- SWE and SA Guidance
  - SoS, SA Guides
- SWE and SA Education and Training
  - DAU SW Acq Curriculum
  - Continuous Learning Modules for SWE, SoS, SA
- Software Engineering
  - Acquisition Support
  - Software Engineering Institute (SEI)
- Process Improvement
  - CMMI Sponsor
- DoD/National Software Investment Strategy

Deputy Director Assessments & Support
Dave Castellano SES

CORE COMPETENCIES

- Support of ACAT I and Other Special Interest Programs (MDAP, MAIS)
- Assessment Methodology (Program Support Reviews - PSRs)
- T&E Oversight and Assessment of Operational Test Readiness (AOTR)
- Systems Engineering and Developmental Test Planning and Support
- Lean/6-Sigma Training/Cert

Acquisition program excellence through sound systems and software engineering

Potential SE Research Focus Areas

- Better integration of SE processes, methodologies, and tools
  - Consideration of toolsets to full system life cycle (CONOPS analysis through sustainment)
  - Extensibility of modeling languages and tools to SE and program artifacts
  - Technical Baseline management tools
  - Data standards alignment with other domains (logistics, test, ops analysis)
  - Enabling EVM, Risk Management, cost estimating, etc
- Alignment of systems engineering and software standards (15288, 12207, 632, 1220, etc)
- SE considerations in complex Systems of Systems environment
  - Large systems, distributed systems, software intensive systems, net-centric ops
- Enterprise-wide SE considerations
- Linking of architectures with SE products/technical baselines

Potential SE Research Focus Areas

- SE's Return on Investment (ROI)
  - Relationship of investment in SE effort to reduction in life cycle costs/program predictability
  - Metrics that support technical decisions and ROI
- Knowledge management SE repositories
  - Mechanisms to advance and share the state-of-the-practice
- Lean Six Sigma opportunities on SE processes
- SE application on services contracts
- Graduate/Continuing Education SE education needs
- SE for governance and strategic choices (investment)
  - Advanced training concepts

The Effectiveness of Systems Engineering:

On Federal System Development Programs

First Public Release

Of Major New NDIA Study by

The Systems Engineering Effectiveness Committee

(SEEC)

Al Mink

SEEC Member

& SRA International

October 2007

The SE Effectiveness Survey

Quantifies the relationship between the application of <u>Systems Engineering</u> best practices and the <u>performance</u> of system development projects

Projects with better Systems Engineering capabilities deliver better Project Performance!

TODAY'S OUTLINE

1. **The Challenge**
2. **The Rigor**
3. **The Results!**
4. **Conclusions & Caveats**

The Challenge
Stakeholder Analysis

Those interested in such a study – and their interests

Customers
- DoD #1 SE Issue – “Inconsistent SE Practices across life cycle”
- Validate initiatives to revitalize SE
- Increase emphasis of SE content in RFPs and Proposals

Industry (System Developers & Integrators)
- Proposal may skimp on SE; Budget pressures on SE

Associations & Academia
- Unable to fully satisfy their members and students

SE professionals
- Lack rigorous justification for their recommendations

The Challenge

Previous Studies – Partial Insights

Gruhl, National Avionics and Space Administration (NASA), 1992

Compared upfront expenditures to eventual cost growth

Herbsleb, Software Engineering Institute (SEI), 1994

Studied ROI on process improvement in software

Honour, International Council on Systems Engineering (INCOSE), 2002

Surveyed industry to compare SE Effort to cost & schedule

Valerdi & Boehm, Constructive System Engineering Cost Model (COSYSMO), 2004

Developed parametric estimation model similar to COCOMO

Boehm & Valerdi, SE ROI (COCOMO), 2006

Analyzed SE activities from COCOMO II

Others…

The Challenge

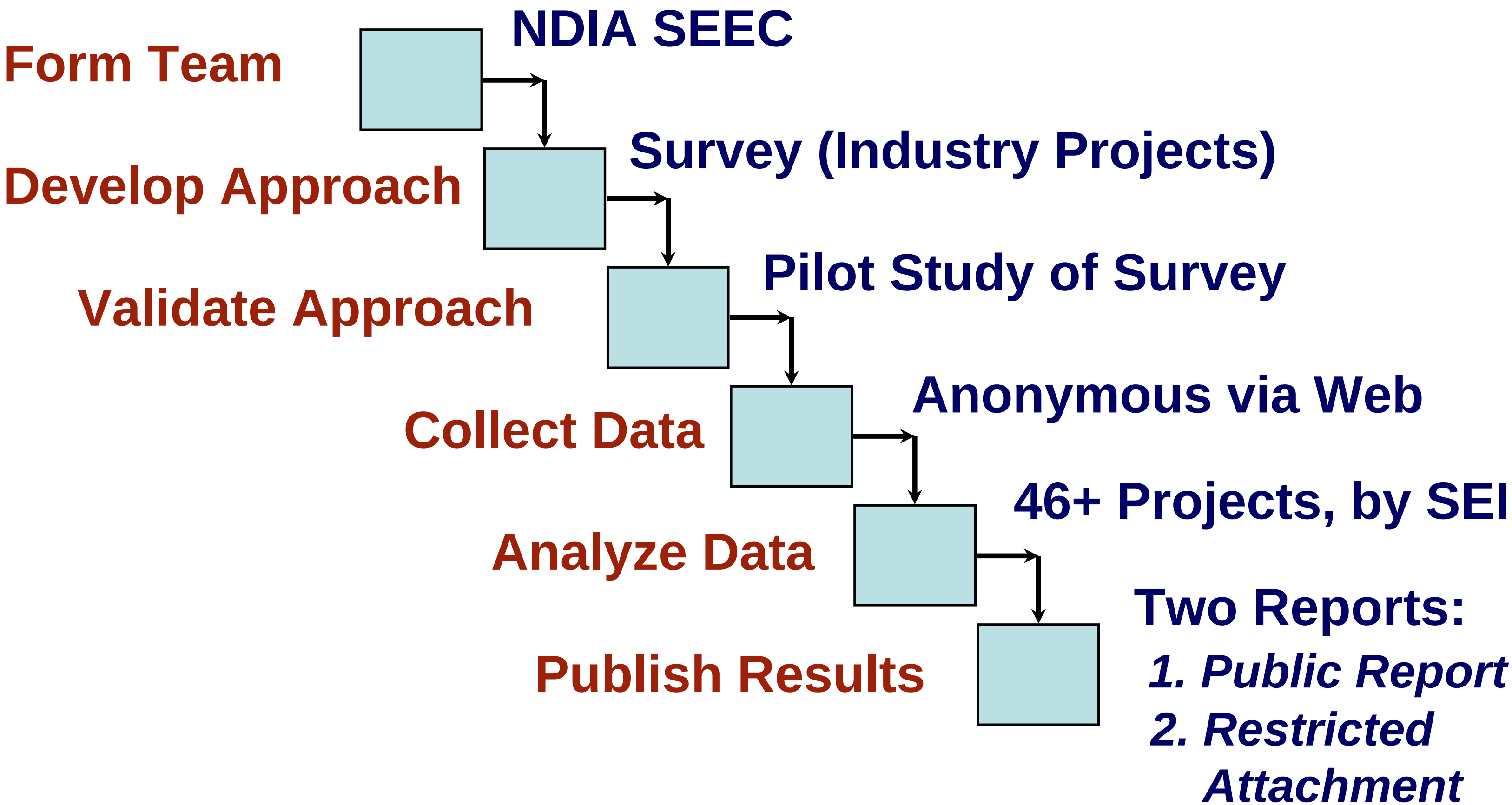
Previous Studies – Summary

STUDY		APPLICABILITY		
Author & Background	**Findings**	**SE Activities**	**Definition of Success**	**Characteristics of Project**
Gruhl (1992) 32 NASA Pgms	8-15% Upfront Best	First two of five development phases	Cost (Less cost overrun)	Large; Complex; all NASA
Herbsleb (1994) 13 CMM Companies	Process Improvement ROI 4.0 – 8.8	CMM Process Areas	Cost (Cost reduction through SE investment)	Various; federal contracting
Honour (2004) Survey INCOSE SEs	15-20% of project should be SE	Overall SE level of effort (Cost) & related SE quality	Cost & Schedule	Various sizes (measured by total project cost)
Boehm & Valerdi (2006) COCOMO II	SE importance grows with project size	COCOMO II RESL (Architecture and Risk)	Cost	Various sizes, but software systems only
Boehm & Valerdi (2004) COSYSMO	Estimate within 30% effort 50% - 70% of time	33 activities defined by EIA 632	Cost	Mostly successful projects from federal contractors
Ancona & Caldwell (1990) Boundary Management	Managing team boundary 15%; more is better	Team boundary activities – interface between team and external	Product Performance (Successfully marketed products)	Technology products
Frantz (1995) Boeing side-by-side projects	More SE yielded better quality & shorter duration	Defined by Frantz	Product Performance & Schedule (Quality of product and duration of project)	Three similar systems for manipulating airframes during assembly

Mink, 2007

The Rigor

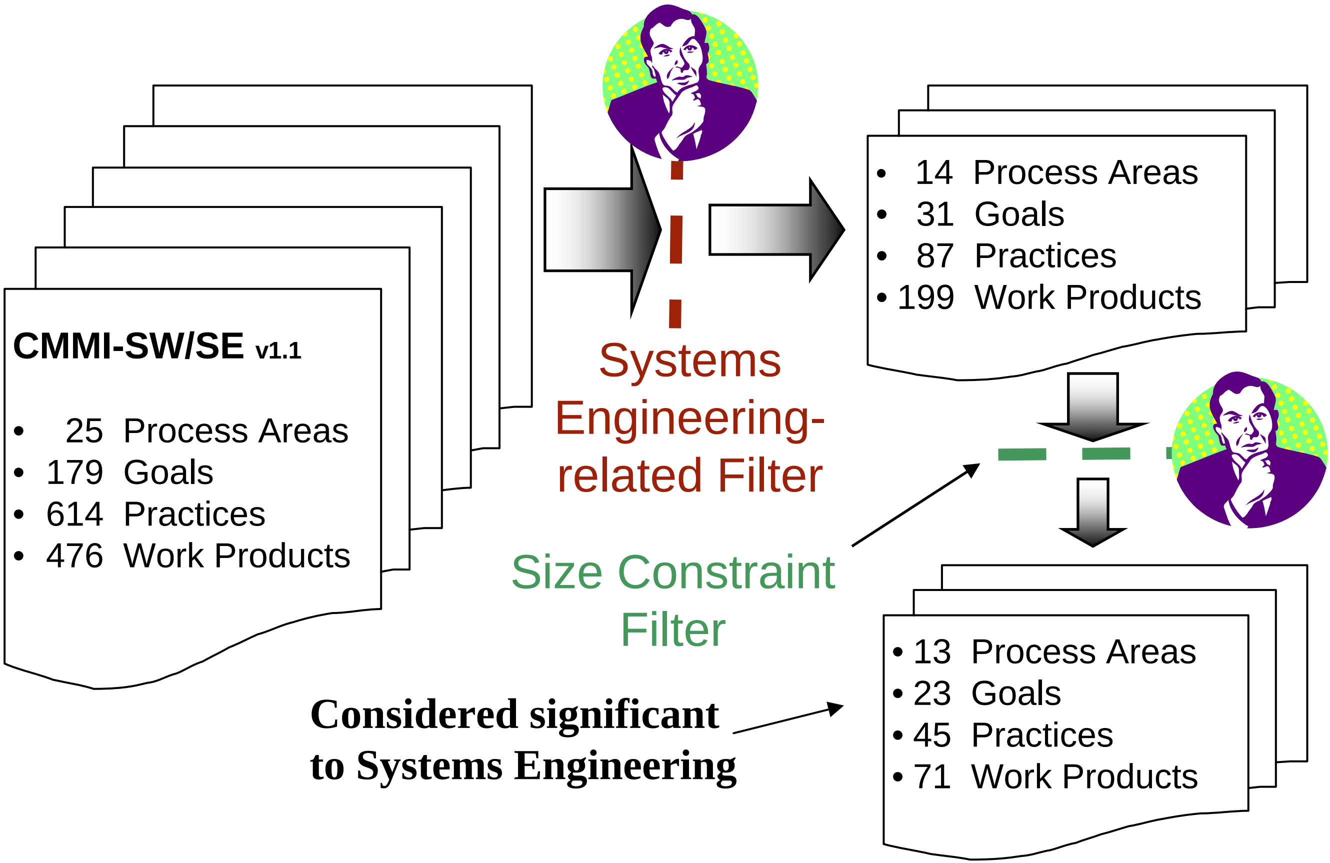
Followed Planned Lifecycle



This study spanned three years

The Rigor

Formally Selected Set of SE Activities



Survey was developed based on standards and recognized SE experts

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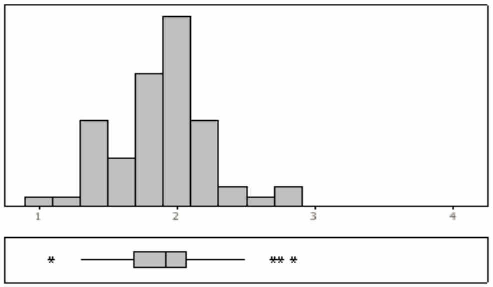
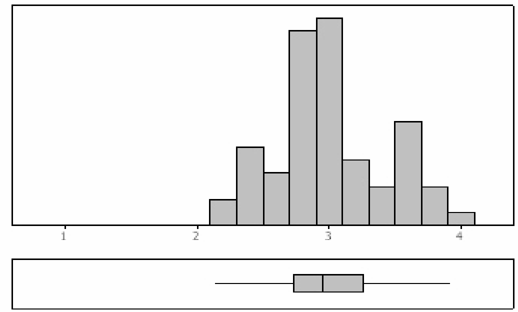
The Rigor

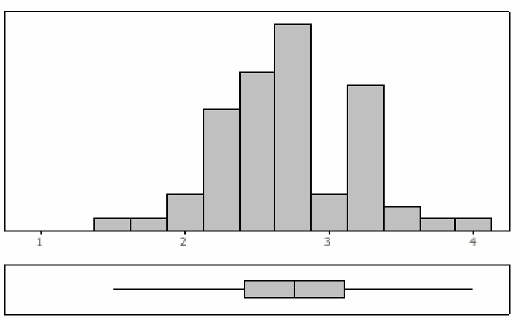
Validated Survey Responses



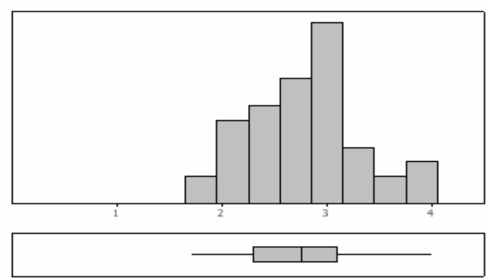
Maximum = 2.8
3^{rd} Quartile = 2.1
Median = 1.9
1^{st} Quartile = 1.7
Minimum = 1.1
N = 64



Maximum = 3.9
3^{rd} Quartile = 3.3
Median = 3.0
1^{st} Quartile = 2.7
Minimum = 2.1
N = 63



Maximum = 4.0
3^{rd} Quartile = 3.1
Median = 2.8
1^{st} Quartile = 2.4
Minimum = 1.5
N = 64

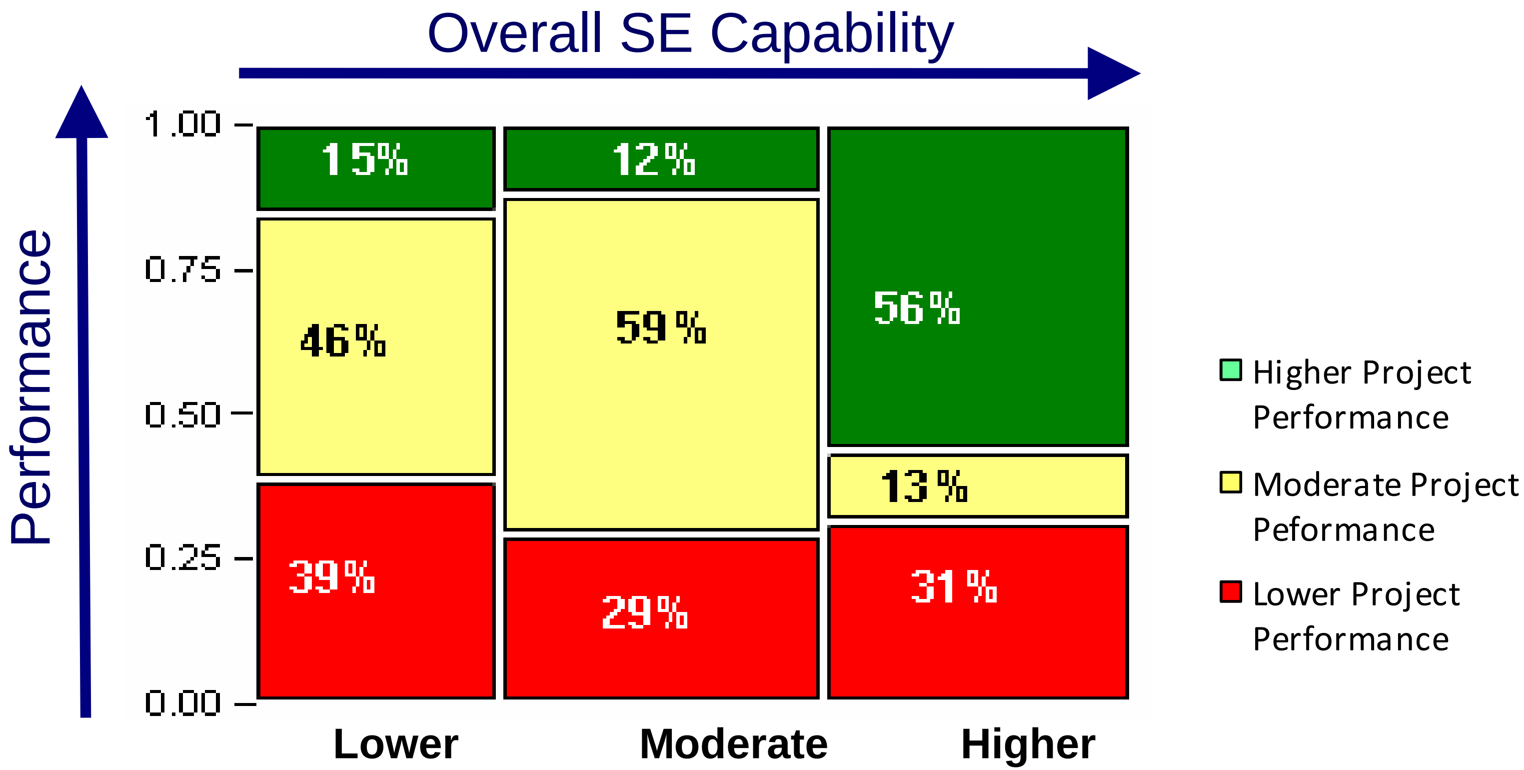


Maximum = 4.0
3^{rd} Quartile = 3.1
Median = 2.75
1^{st} Quartile = 2.3
Minimum = 1.7
N = 46

Analyzed distributions, variability, relationships…
To ensure statistical rigor and relevance

Results

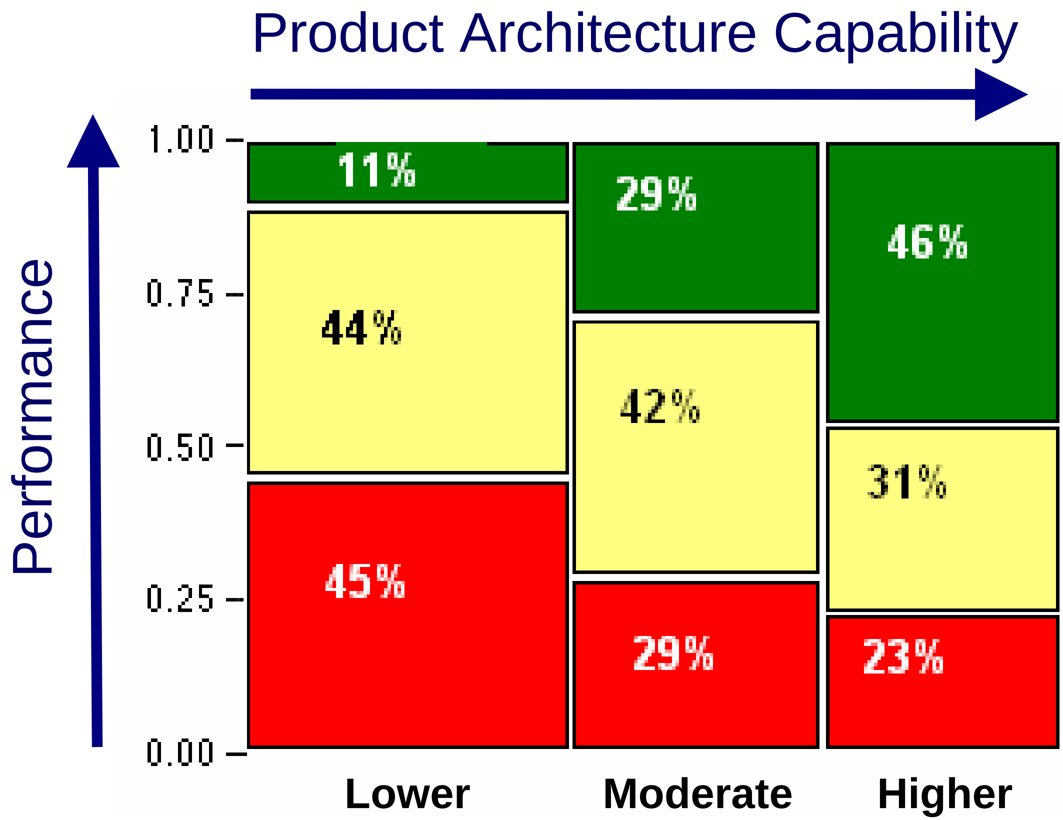
Overall SE Capability & Project Performance



Projects with better <u>Overall Systems Engineering Capability</u> delivers better Project Performance *(cost, schedule and scope)*

Results

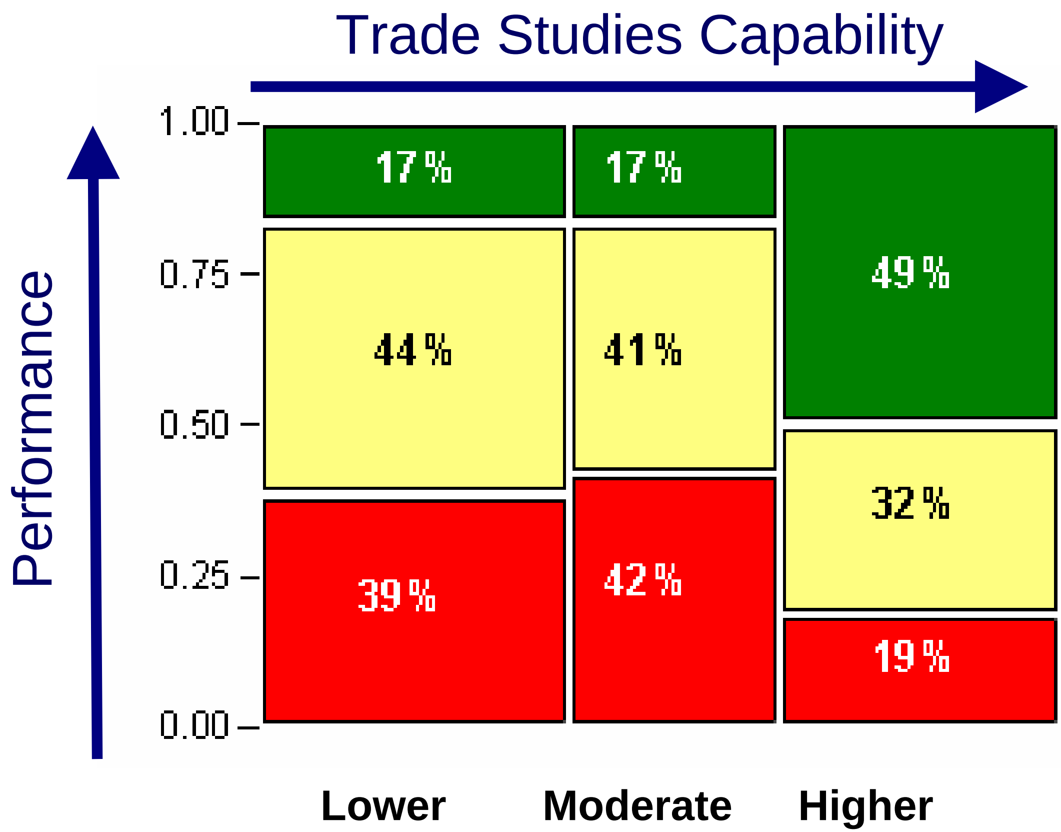
1. Product Architecture and Project Performance



Projects with better Product Architecture Capability Show a "Moderately Strong / Strong" Positive Relationship with Performance

Results

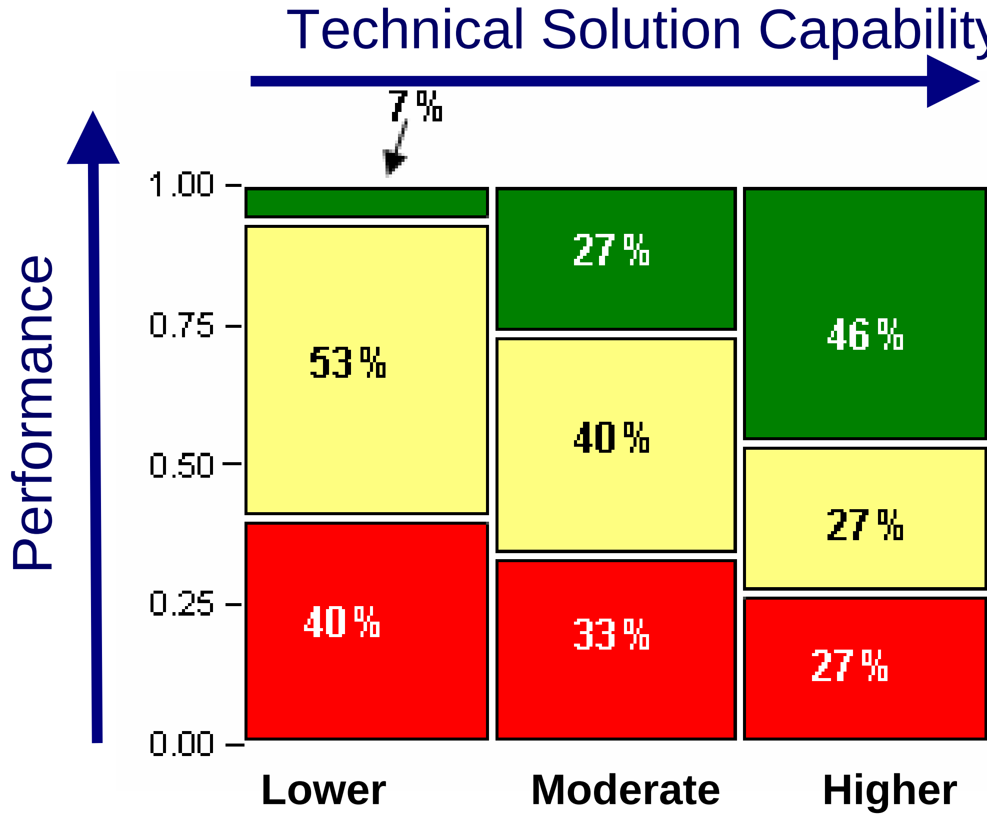
2. Trade Studies and Project Performance



Projects with better Trade Studies Capability Show a "Moderately Strong / Strong" Positive Relationship with Performance

Results

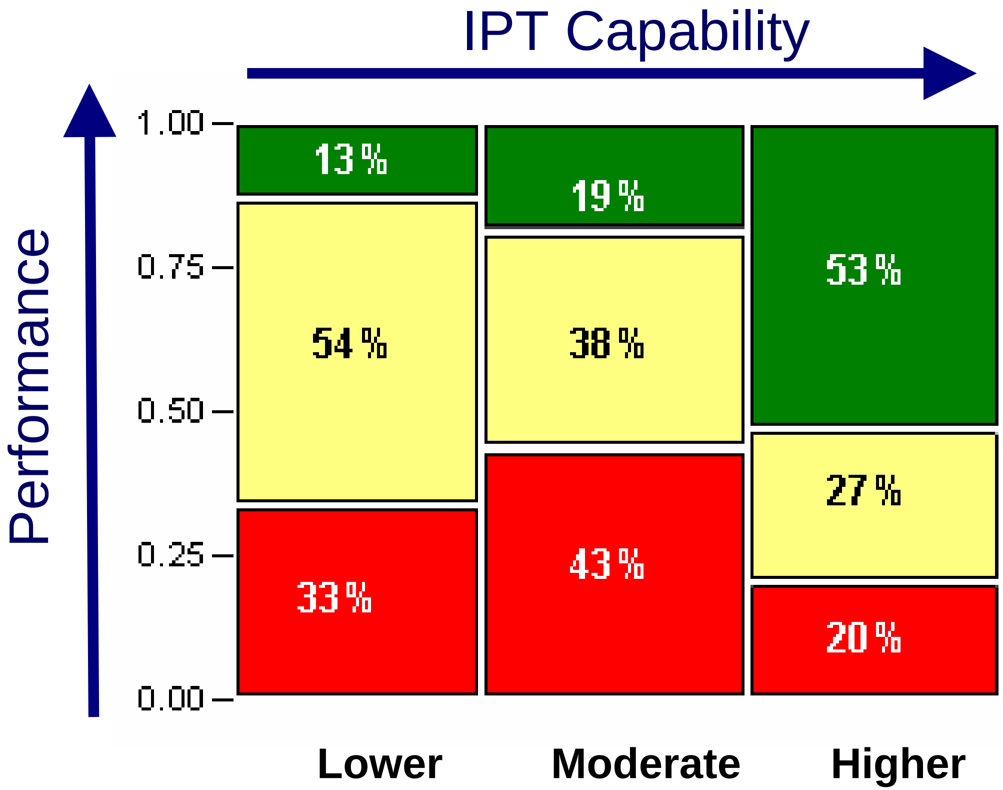
3. Technical Solution and Project Performance



Projects with better <u>Technical Solution</u> Capability Show a <u>"Moderately Strong / Strong" Positive Relationship</u> with Performance

Results

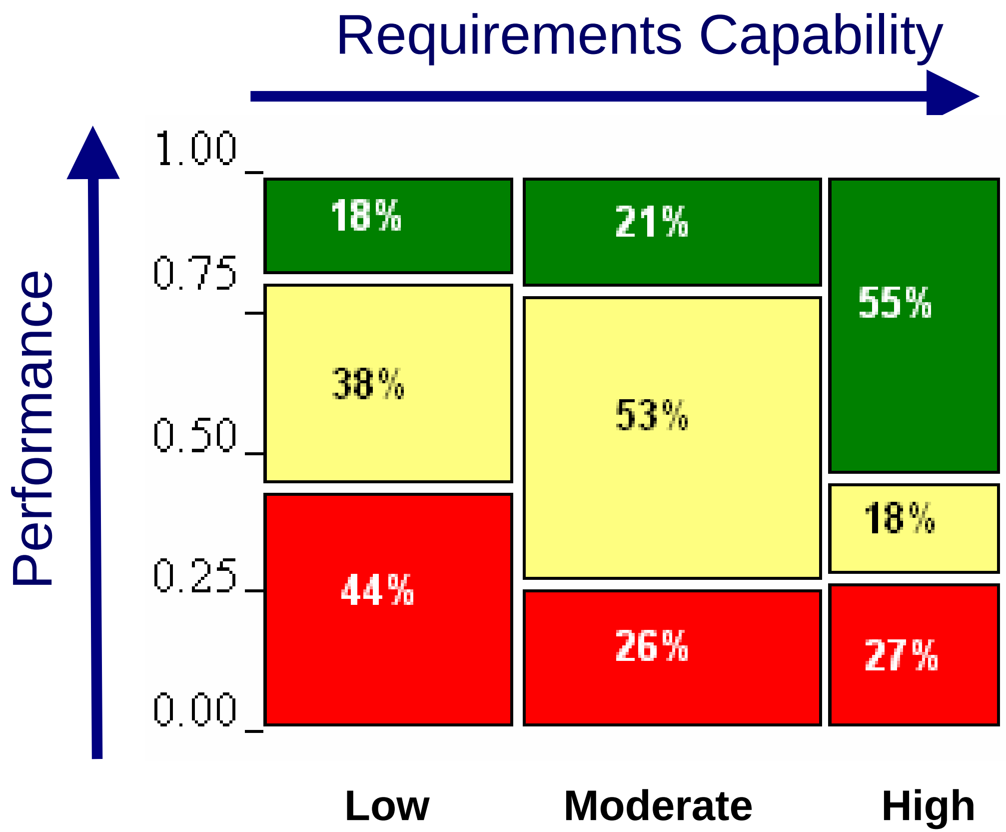
4. IPTs and Project Performance



Projects with better IPTs Capability Show a "Moderately Strong / Strong" Positive Relationship with Performance

Results

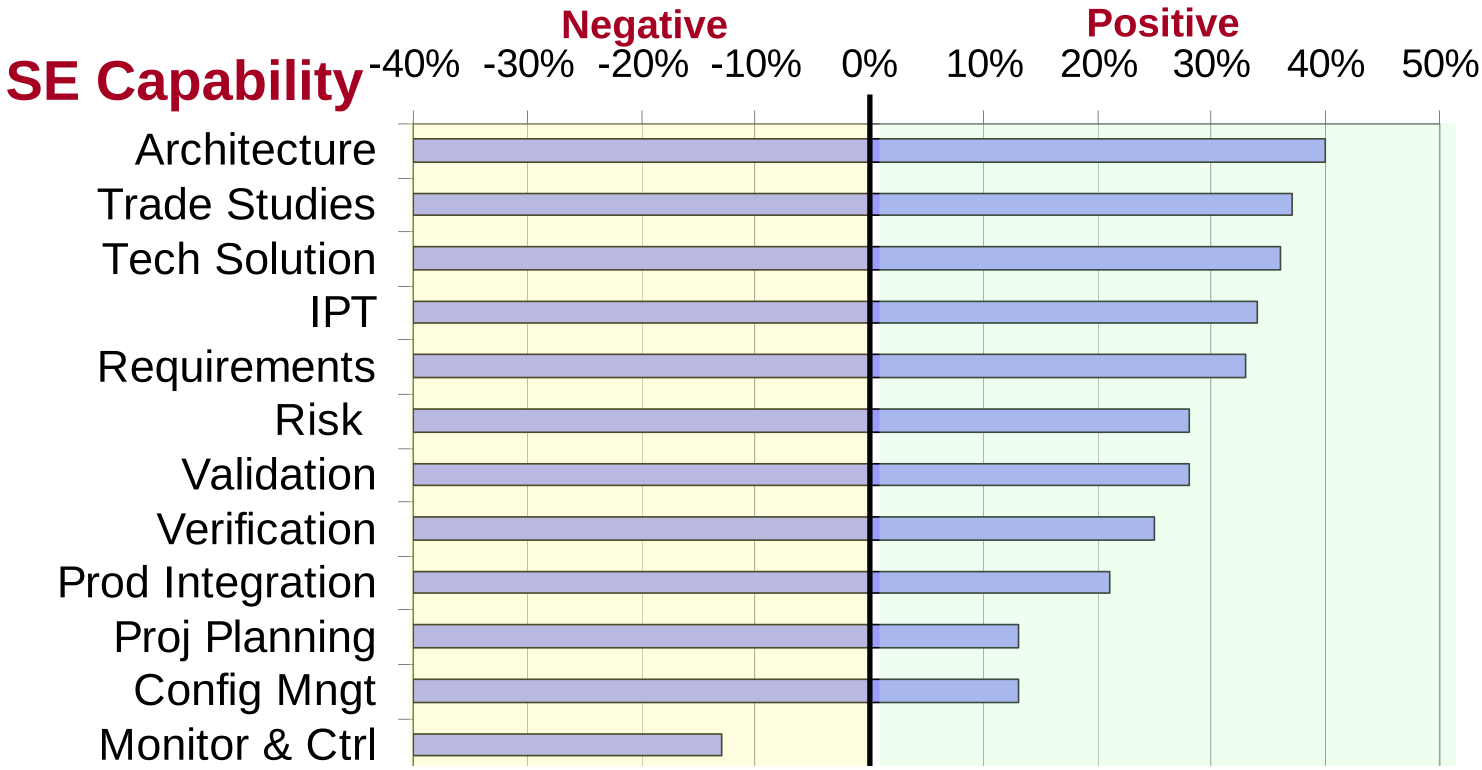
5. Requirements and Project Performance



Projects with better Requirements Management and Development Capability Show a "Moderately Strong / Strong" Positive Relationship with Performance

Results

Summary of Relationships



Relationship to Performance (Gamma)

Conclusions & Caveats

Summary

SE Effectiveness

- Provides credible measured evidence about the value of disciplined Systems Engineering
- Affects success of systems-development projects

Specific Systems Engineering Best Practices

- Highest relationships to activities on the “left side of SE Vee”

Environment (Project Challenge) affects performance too

  - Some projects are more challenging than others ... and higher challenge affects performance negatively
  - Yet good SE practices remain crucial for both high and low challenge projects

Conclusions & Caveats

Next Steps

- **Correlate Report Findings with Other Sources**
- **Develop Improvement Recommendations**
  - Policy, guidance, training, measures, reviews
- **Conduct Additional Analysis of Collected Data**
  - IV & V
  - Discover other relationships and correlations
- **Repeat the Survey to Gauge Improvements**
- **Survey Acquirers**

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Acknowledgements

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Backup

NDIA SE Effectiveness Survey Analysis Slides

Reference: "A Survey of Systems Engineering Effectiveness", Software Engineering Institute, Carnegie Mellon University, CMU/SEI-2007-SR-008. Joseph P. Elm, Dennis R. Goldenson, Khaled El Emam, Nicole Donatelli, Angelica Nissa.

Conclusions & Caveats

Consistent with "Top 10 Reasons Projects Fail"*

1. Lack of user involvement
2. Changing requirements
3. Inadequate Specifications
4. Unrealistic project estimates
5. Poor project management
6. Management change control
7. Inexperienced personnel
8. Expectations not properly set
9. Subcontractor failure
10. Poor architectural design

Above Items Can Cause Overall Program Cost and Schedule to Overrun

*** Project Management Institute**

Matching items noted in RED

Conclusions & Caveats

Consistent with "Top 5 SE Issues" (2006)*

- Key systems engineering practices known to be effective are not consistently applied across all phases of the program life cycle.

- Insufficient systems engineering is applied early in the program life cycle, compromising the foundation for initial requirements and architecture development.

- Requirements are not always well-managed, including the effective translation from capabilities statements into executable requirements to achieve successful acquisition programs.

- The quantity and quality of systems engineering expertise is insufficient to meet the demands of the government and the defense industry.

- Collaborative environments, including SE tools, are inadequate to effectively execute SE at the joint capability, system of systems, and system levels.

* OUSD AT&L Summit

Matching items noted in RED

Summary SE Relationships to Project Performance

Relative Project Performance

Details

	Gamma	p	Lower					Moderate					Higher				
			Min. Range	# Lo	# Med	# Hi	Max. Range	Min. Range	# Lo	# Med	# Hi	Max. Range	Min. Range	# Lo	# Med	# Hi	Max. Range
Project Challenge																	
PC	-31%	5.0%	1.0	22%	28%	50%	1.85	1.85	42%	58%	0%	2.05	2.05	38%	38%	25%	4.0
Project Environment																	
CMMI	22%	13.0%	1.0	36%	57%	7%	1.95	1.95	29%	36%	35%	2.7	2.7	33%	28%	39%	4.0
IMP	5%	39.0%	1.0	25%	55%	20%	2.17	2.17	42%	29%	29%	2.84	2.84	33%	25%	42%	4.0
EXP	9%	33.0%	1.0	29%	42%	29%	2.5	2.5	39%	44%	17%	3.5	3.5	29%	29%	42%	4.0
Systems Engineering Capability																	
IPT	34%	4.0%	1.0	33%	54%	13%	2.5	2.5	43%	38%	19%	3.1	3.1	20%	27%	53%	4.0
PP	13%	25.0%	1.0	33%	54%	13%	2.8	2.8	29%	35%	36%	3.3	3.3	35%	29%	36%	4.0
PMC	-13%	25.0%	1.0	23%	54%	23%	2.5	2.5	23%	46%	31%	3.0	3.0	45%	25%	30%	4.0
RSKM	28%	6.1%	1.0	35%	47%	18%	2.8	2.8	27%	66%	7%	3.6	3.6	36%	0%	64%	4.0
REQ	33%	4.0%	1.0	44%	38%	18%	2.8	2.8	26%	53%	21%	3.4	3.4	27%	18%	55%	4.0
TRADE	37%	3.0%	1.0	39%	44%	17%	2.7	2.7	42%	41%	17%	3.3	3.3	19%	32%	49%	4.0
ARCH	40%	0.2%	1.0	45%	44%	11%	2.7	2.7	29%	42%	29%	3.3	3.3	23%	31%	46%	4.0
TS	36%	3.0%	1.0	40%	53%	7%	2.8	2.8	33%	40%	27%	3.2	3.2	27%	27%	46%	4.0
PI	21%	16.0%	1.0	36%	54%	14%	1.5	1.5	33%	38%	29%	3.5	3.5	29%	29%	42%	4.0
VER	25%	9.0%	1.0	31%	62%	7%	2.7	2.7	33%	34%	33%	3.2	3.2	33%	20%	47%	4.0
VAL	28%	7.0%	1.0	54%	23%	23%	2.7	2.7	17%	66%	17%	3.3	3.3	29%	33%	38%	4.0
CM	13%	26.0%	1.0	29%	47%	24%	3.0	3.0	46%	36%	18%	3.67	3.67	28%	33%	39%	4.0
Overall SEC	32%	4.0%	1.0	39%	46%	15%	2.5	2.5	29%	59%	12%	3.0	3.0	31%	13%	56%	4.0
REQ+TS	49%	0.5%	1.0	43%	50%	13%	2.8	2.8	23%	62%	15%	3.1	3.1	22%	28%	50%	4.0
Acquirer Capability																	
AC	-35%	3.0%	1.0	7%	60%	33%	2.5	2.5	41%	32%	26%	3.0	3.0	50%	25%	25%	4.0
Combined Capability and Challenge																	
REQ+TS+PC	63%	0.0%	1.0	67%	33%	0%	1.7	1.7	25%	45%	30%	2.3	2.3	14%	36%	50%	4.0

Gamma relationship	Chance probability
Strong	Very low
Moderately strong to strong	Low
Moderately strong	Moderately low
Weak	Fair

NATIONAL DEFENSE INDUSTRIAL ASSOCIATION
STRENGTH THROUGH INDUSTRY & TECHNOLOGY

Summary SE Relationships to Project Performance

Relative Project Performance

Details

	Gamma	p	Lower Min. Range	Lower # Lo	Lower # Med	Lower # Hi	Lower Max. Range	Moderate Min. Range	Moderate # Lo	Moderate # Med	Moderate # Hi	Moderate Max. Range	Higher Min. Range	Higher # Lo	Higher # Med	Higher # Hi	Higher Max. Range
Project Challenge																	
PC	-31%	5.0%	1.0	22%	28%	50%	1.85	1.85	42%	58%	0%	2.05	2.05	38%	38%	25%	4.0
Project Environment																	
CMMI	22%	13.0%	1.0	36%													
IMP	5%	39.0%	1.0	25%													
EXP	9%	33.0%	1.0	29%													
Systems Engineering Capability																	
IPT	34%	4.0%	1.0	33%	54%	13%	2.5	2.5	43%	38%	19%	3.1	3.1	20%	27%	53%	4.0
PP	13%	25.0%	1.0	33%	54%	13%	2.8	2.8	29%	35%	36%	3.3	3.3	35%	29%	36%	4.0
PMC	-13%	25.0%	1.0	23%	54%	23%	2.5	2.5	23%	46%	31%	3.0	3.0	45%	25%	30%	4.0
RSKM	28%	6.1%	1.0	35%	47%	18%	2.8	2.8	27%	66%	7%	3.6	3.6	36%	0%	64%	4.0
REQ	33%	4.0%	1.0	44%	38%	18%	2.8	2.8	26%	53%	21%	3.4	3.4	27%	18%	55%	4.0
TRADE	37%	3.0%	1.0	39%	44%	17%	2.7	2.7	42%	41%	17%	3.3	3.3	19%	32%	49%	4.0
ARCH	40%	0.2%	1.0	45%	44%	11%	2.7	2.7	29%	42%	29%	3.3	3.3	23%	31%	46%	4.0
TS	36%	3.0%	1.0	40%	53%	7%	2.8	2.8	33%	40%	27%	3.2	3.2	27%	27%	46%	4.0
PI	21%	16.0%	1.0	36%	54%	14%	1.5	1.5	33%	38%	29%	3.5	3.5	29%	29%	42%	4.0
VER	25%	9.0%	1.0	31%	62%	7%	2.7	2.7	33%	34%	33%	3.2	3.2	33%	20%	47%	4.0
VAL	28%	7.0%	1.0	54%	23%	23%	2.7	2.7	17%	66%	17%	3.3	3.3	29%	33%	38%	4.0
CM	13%	26.0%	1.0	29%	47%	24%	3.0	3.0	46%	36%	18%	3.67	3.67	28%	33%	39%	4.0
Overall SEC	32%	4.0%	1.0	39%	46%	15%	2.5	2.5	29%	59%	12%	3.0	3.0	31%	13%	56%	4.0
REQ+TS	49%	0.5%	1.0	43%	50%	13%	2.8	2.8	23%	62%	15%	3.1	3.1	22%	28%	50%	4.0
Acquirer Capability																	
AC	-35														25%	25%	4.0
Combined Capability and																	
REQ+TS+PC	63														36%	50%	4.0

Highest scoring SE capability areas in Higher Performing Projects*: Risk Management; Requirements Development and Management; IPTs

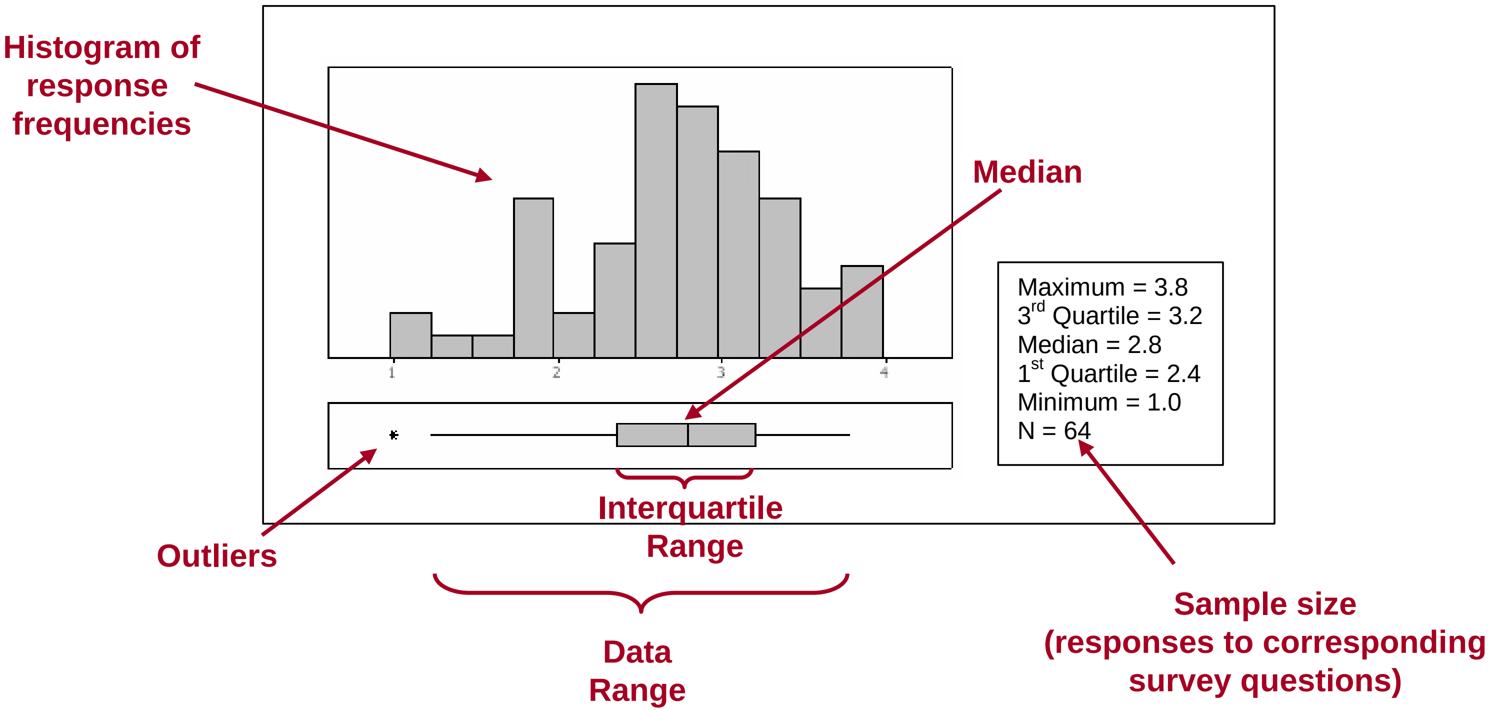
*Based on small partitioned sample size

Lowest scoring SE capability areas in Lower Performing Projects*: Validation; Architecture; Requirements Development and Management

Gamma relationship	Chance probability	Gamma relationship	Chance probability
Strong	Very low	Moderately strong	Moderately low
Moderately strong to strong	Low	Weak	Fair

Terminology and Notation

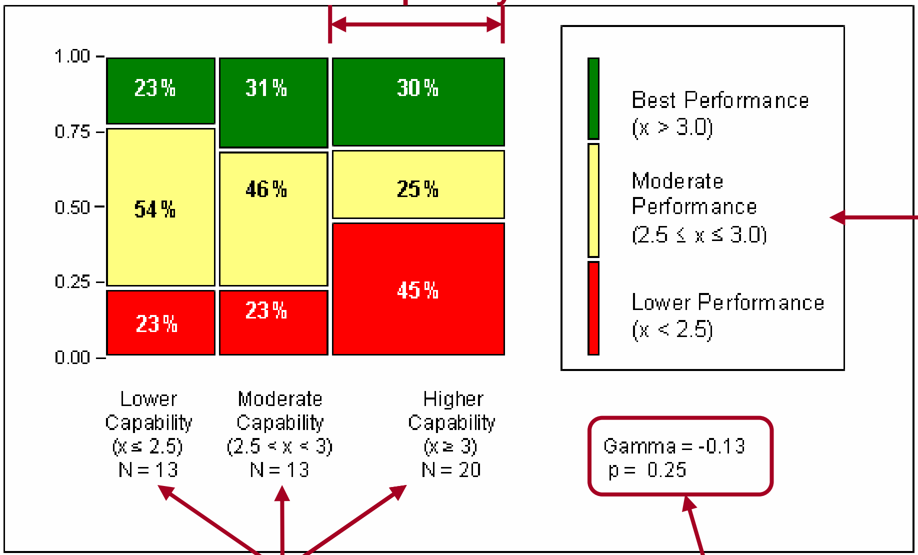
Distribution Graph



Terminology and Notation

Mosaic Chart

Column width represents proportion of projects with this level of capability



Relative performance distribution of the sample

<u>Gamma</u>: measures strength of relationship between two ordinal variables

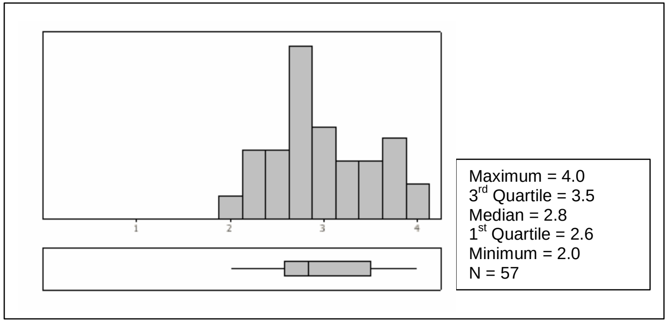
<u>p</u>: probability that an associative relationship would be observed by chance alone

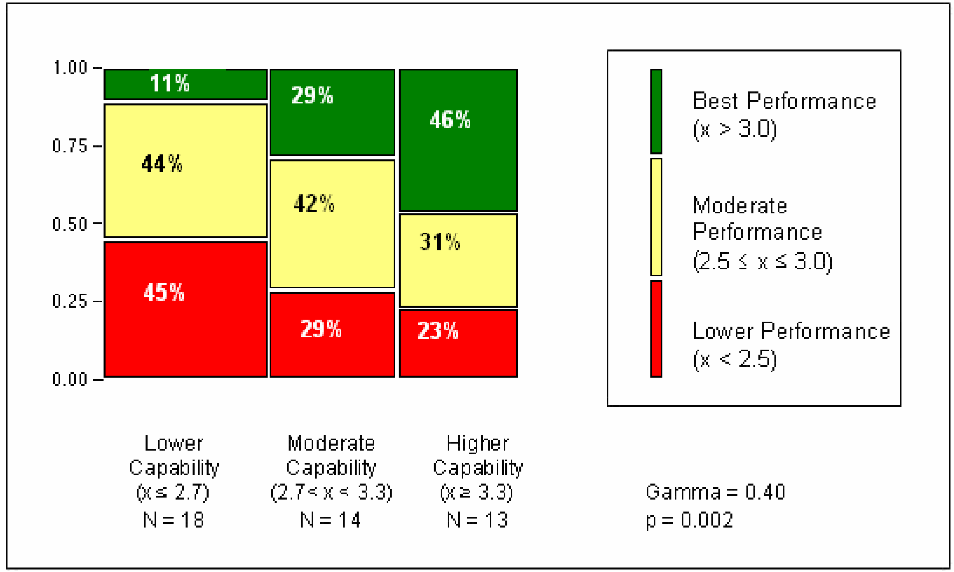
Projects exhibiting a given level of relative capability (Lowest, Intermediate, Highest)

Sample size and distribution for associated survey responses (capability + performance)

Measures of association and statistical test

SE Capability:
Product Architecture (ARCH)





Relationship to project performance:	Moderately strong to strong positive relationship

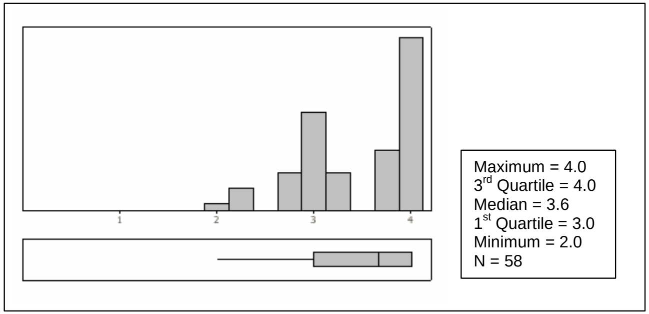
SE Capability

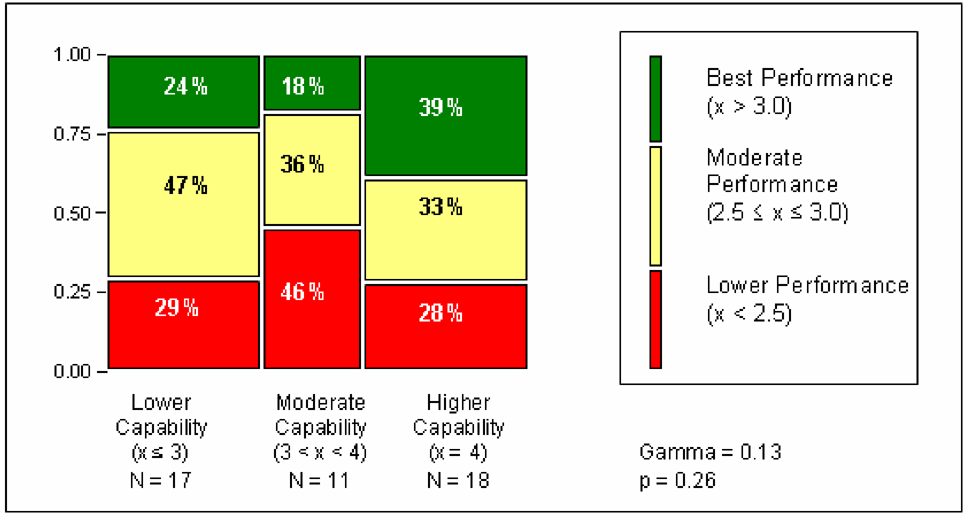
	Gamma	p	Lower					Moderate					Higher				
			Min. Range	# Lo	# Med	# Hi	Max. Range	Min. Range	# Lo	# Med	# Hi	Max. Range	Min. Range	# Lo	# Med	# Hi	Max. Range
ARCH	40%	0.2%	1.0	45%	44%	11%	2.7	2.7	29%	42%	29%	3.3	3.3	23%	31%	46%	4.0

Survey Questions

ID	Question	Response range
IF01	This project maintains accurate and up-to-date descriptions (e.g. interface control documents, models, etc.) defining interfaces in detail	•strongly disagree •disagree •agree •strongly agree
IF02	Interface definition descriptions are maintained in a designated location, under configuration management, and accessible to all who need them	•strongly disagree •disagree •agree •strongly agree
IF03a	For this project, the product high-level structure is documented, kept up to date, and managed under configuration control	•strongly disagree •disagree •agree •strongly agree
IF03b	For this project, the product high-level structure is documented using multiple views (e.g. functional views, module views, etc.	•strongly disagree •disagree •agree •strongly agree
IF03c	For this project, the product high-level structure is accessible to all relevant project personnel	•strongly disagree •disagree •agree •strongly agree
IF04	This project has defined and documented guidelines for choosing COTS product components	•strongly disagree •disagree •agree •strongly agree

SE Capability: Configuration Management (CM)





Relationship to project performance:	Weak positive relationship

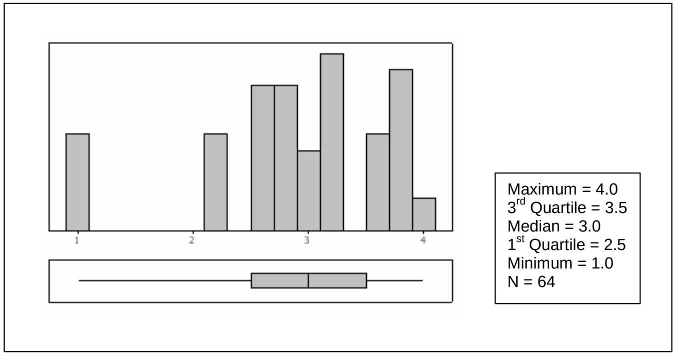
SE Capability

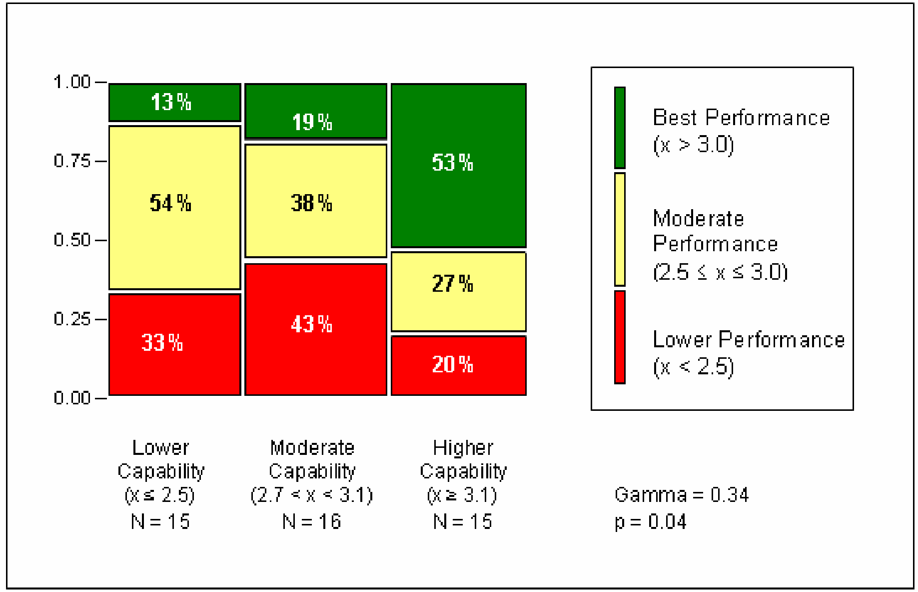
	Gamma	p	Lower					Moderate					Higher				
			Min. Range	# Lo	# Med	# Hi	Max. Range	Min. Range	# Lo	# Med	# Hi	Max. Range	Min. Range	# Lo	# Med	# Hi	Max. Range
CM	13%	26.0%	1.0	29%	47%	24%	3.0	3.0	46%	36%	18%	3.67	3.67	28%	33%	39%	4.0

Survey Questions

ID	Question	Response Range
V&V06	This project has a configuration management system that charters a Change Control Board to disposition change requests	•strongly disagree •disagree •agree •strongly agree
V&V07	This project maintains records of requested and implemented changes to configuration-managed items	•strongly disagree •disagree •agree •strongly agree
V&V08	This project creates and manages configuration baselines (e.g., functional, allocated, product)	•strongly disagree •disagree •agree •strongly agree

SE Capability:
IPT-Related Capability (IPT)





Relationship to project performance:	Moderately strong positive relationship

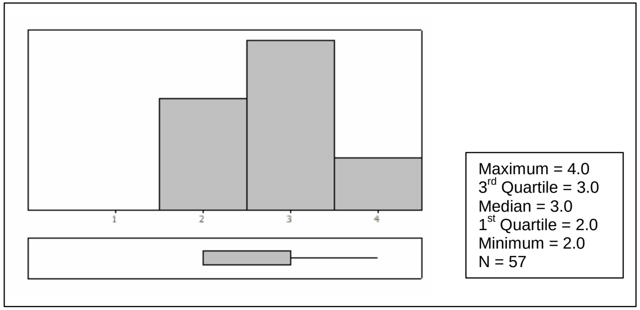
SE Capability

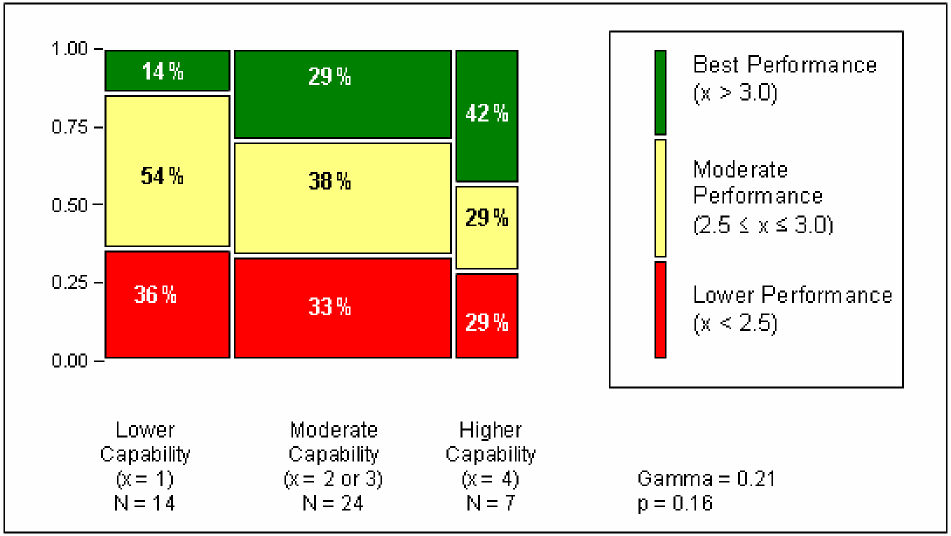
	Gamma	p	Lower Min. Range	Lower # Lo	Lower # Med	Lower # Hi	Lower Max. Range	Moderate Min. Range	Moderate # Lo	Moderate # Med	Moderate # Hi	Moderate Max. Range	Higher Min. Range	Higher # Lo	Higher # Med	Higher # Hi	Higher Max. Range
IPT	34%	4.0%	1.0	33%	54%	13%	2.5	2.5	43%	38%	19%	3.1	3.1	20%	27%	53%	4.0

Survey Questions

ID	Question	Response range
Proj03	This project uses integrated product teams (IPTs)	•Yes •No
Proj04	This project makes effective use of integrated product teams (IPTs)	•highly compliant •largely compliant; •moderately compliant •not compliant
Proj06	My suppliers actively participate in IPTs	•highly compliant •largely compliant; •moderately compliant •not compliant
Proj07a	This project has an IPT with assigned responsibility for systems engineering	•highly compliant •largely compliant; •moderately compliant •not compliant
Proj07b	This project has Systems Engineering representation on each IPT	•highly compliant •largely compliant; •moderately compliant •not compliant

SE Capability:
Product Integration (PI)





Relationship to project performance:	Weak positive relationship

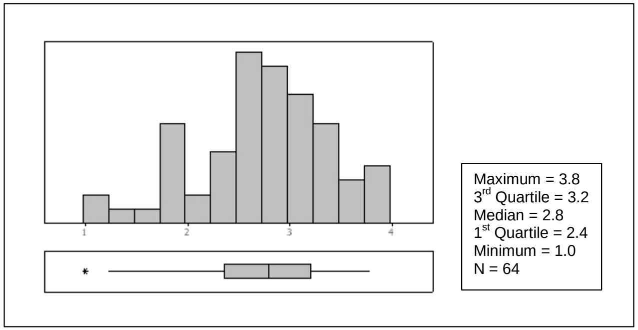
SE Capability

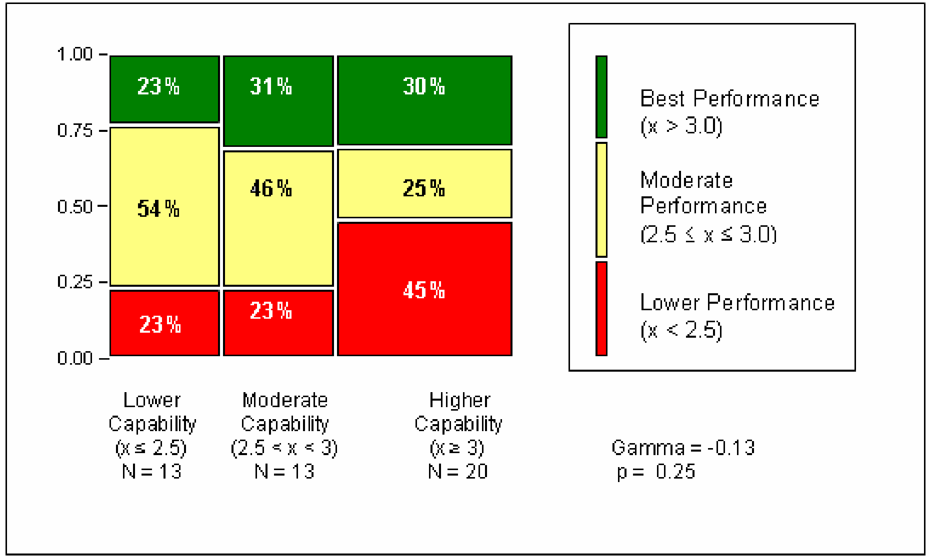
	Gamma	p	Lower					Moderate					Higher				
			Min. Range	# Lo	# Med	# Hi	Max. Range	Min. Range	# Lo	# Med	# Hi	Max. Range	Min. Range	# Lo	# Med	# Hi	Max. Range
PI	21%	16.0%	1.0	36%	54%	14%	1.5	1.5	33%	38%	29%	3.5	3.5	29%	29%	42%	4.0

Survey Question

ID	Question	Response range
IF05	This project has accurate and up-to-date documents defining its product integration process, plans, criteria, etc. throughout the life cycle	•strongly disagree •disagree •agree •strongly agree

SE Capability:
Project Monitoring and Control (PMC)





Relationship to project performance:	Weak negative relationship

SE Capability

	Gamma	p	Lower Min. Range	Lower # Lo	Lower # Med	Lower # Hi	Lower Max. Range	Moderate Min. Range	Moderate # Lo	Moderate # Med	Moderate # Hi	Moderate Max. Range	Higher Min. Range	Higher # Lo	Higher # Med	Higher # Hi	Higher Max. Range
PMC	-13%	25.0%	1.0	23%	54%	23%	2.5	2.5	23%	46%	31%	3.0	3.0	45%	25%	30%	4.0

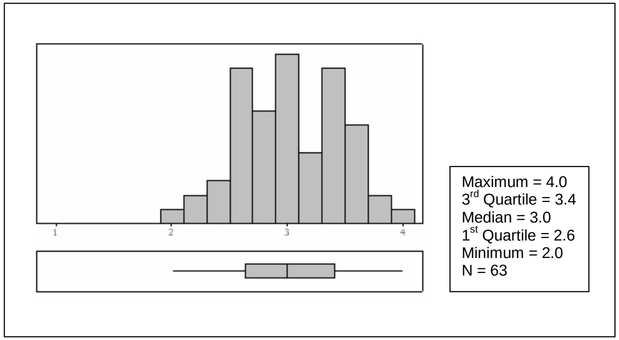
Survey Questions (Part 1)

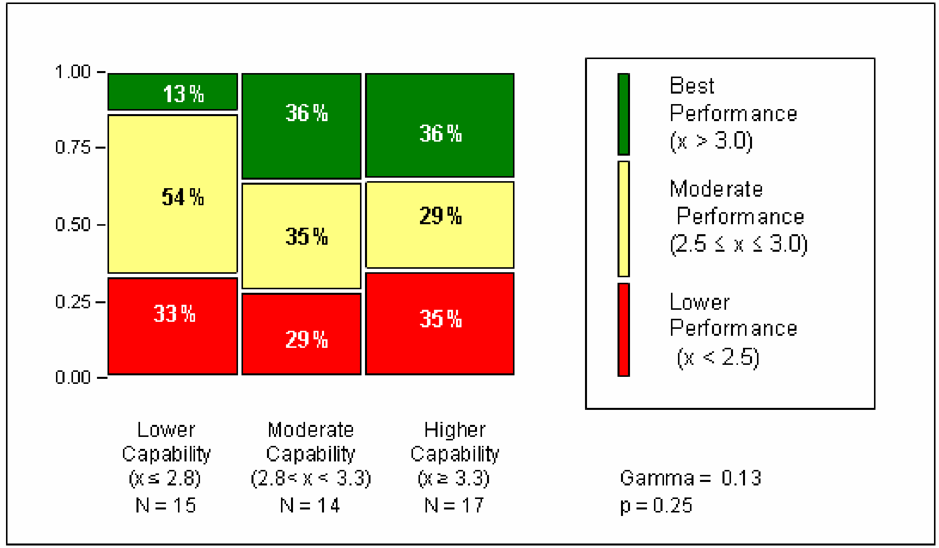
ID	Question	Response range
Cont13	Do you separately cost and track systems engineering activities?	Yes No
Cont14a	Approximately what percentage of non-recurring engineering (NRE) does systems engineering represent?	Percentages quantized as: •<= 5% •<= 10% •<= 15% •<= 25% •> 25%
Cont14b	Is the NRE percentage estimated, or is it a measured value?	•estimated •measured
Perf01	This project creates and manages cost and schedule baselines	•strongly disagree •disagree •agree •strongly agree
Perf02b	EVMS data are available to decision makers in a timely manner (i.e. current within 2 weeks)	•strongly disagree •disagree •agree •strongly agree
Perf02c	The requirement to track and report EVMS data is levied upon the project's suppliers	•strongly disagree •disagree •agree •strongly agree
Perf02d	Variance thresholds for CPI and SPI variance are defined, documented, and used to determine when corrective action is needed	•strongly disagree •disagree •agree •strongly agree

Survey Questions (Part 2)

<table>
<tr><th>ID</th><th>Question</th><th colspan="2">Response range</th></tr>
<tr><td>Perf02e</td><td>EVMS is linked to the technical effort through the WBS and the IMP/IMS</td><td colspan="2">•strongly disagree
•disagree
•agree
•strongly agree</td></tr>
<tr><td>OPerf05</td><td>Does this project track reports of problems from fielded items?</td><td>•Yes
•No</td><td rowspan="3">Scored by the number of positive responses</td></tr>
<tr><td>OPerf06</td><td>Does the project conduct an engineering assessment of all field trouble reports?</td><td>•Yes
•No</td></tr>
<tr><td>OPerf07</td><td>The results of this engineering assessment feed into …</td><td>•operational hazard risk assessments
•materiel readiness assessments
•system upgrades planning
•other</td></tr>
</table>

SE Capability:
Project Planning (PP)





Relationship to project performance:	Weak positive relationship

SE Capability

			Lower					Moderate					Higher				
	Gamma	p	Min. Range	# Lo	# Med	# Hi	Max. Range	Min. Range	# Lo	# Med	# Hi	Max. Range	Min. Range	# Lo	# Med	# Hi	Max. Range
PP	13%	25.0%	1.0	33%	54%	13%	2.8	2.8	29%	35%	36%	3.3	3.3	35%	29%	36%	4.0

Survey Questions (Part 1)

ID	Question	Response range
PD01	This project utilizes a documented set of systems engineering processes for the planning and execution of the project	•strongly disagree •disagree •agree •strongly agree
PD02a	This project has an accurate and up-to-date Work Breakdown Structure (WBS) that includes task descriptions and work package descriptions	•strongly disagree •disagree •agree •strongly agree
PD02b	This project has an accurate and up-to-date Work Breakdown Structure (WBS) that is based upon the product structure	•strongly disagree •disagree •agree •strongly agree
PD02c	This project has an accurate and up-to-date Work Breakdown Structure (WBS) that is developed with the active participation of those who perform the systems engineering activities	•strongly disagree •disagree •agree •strongly agree
PD02d	This project has an accurate and up-to-date Work Breakdown Structure (WBS) that is developed with the active participation of all relevant stakeholders, e.g., developers, maintainers, testers, inspectors, etc.	•strongly disagree •disagree •agree •strongly agree
PD03a	This project's Technical Approach (i.e. a top-level strategy and methodology to create the initial conceptual design for product development) is complete, accurate and up-to-date	•strongly disagree •disagree •agree •strongly agree
PD03b	This project's Technical Approach (i.e. a top-level strategy and methodology to create the initial conceptual design for product development) is developed with the active participation of those who perform the systems engineering activities	•strongly disagree •disagree •agree •strongly agree
PD03c	This project's Technical Approach (i.e. a top-level strategy and methodology to create the initial conceptual design for product development) is developed with the active participation of all appropriate functional stakeholder	•strongly disagree •disagree •agree •strongly agree

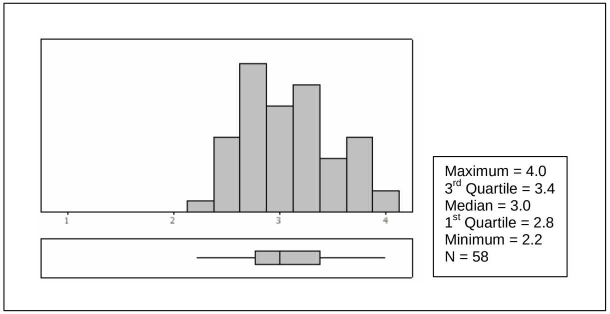
Survey Questions (Part 2)

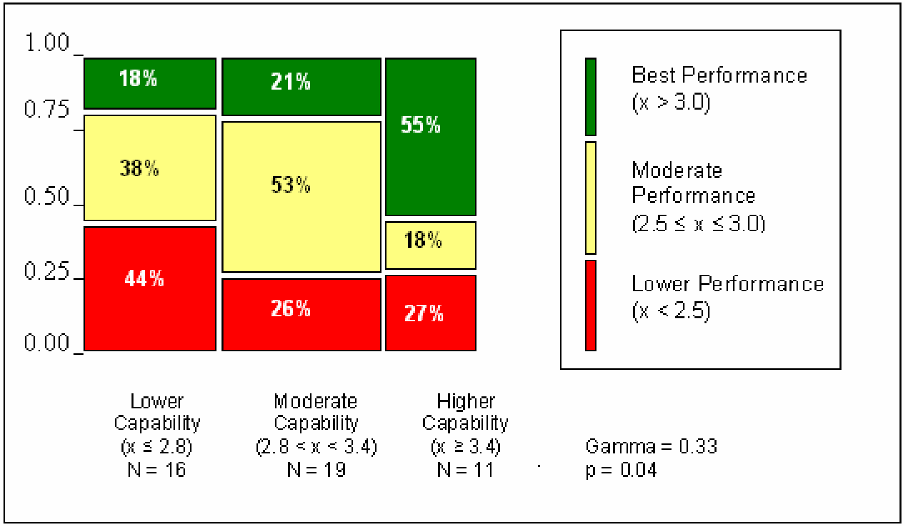
ID	Question	Response range
PD04a	This project has a top-level plan, such as an Integrated Master Plan (IMP), that is an event-driven plan (i.e., each accomplishment is tied to a key project event)	•strongly disagree •disagree •agree •strongly agree
PD04b	This project has a top-level plan, such as an Integrated Master Plan (IMP), that documents significant accomplishments with pass/fail criteria for both business and technical elements of the project	•strongly disagree •disagree •agree •strongly agree
PD04c	This project has a top-level plan, such as an Integrated Master Plan (IMP), that is consistent with the WBS	•strongly disagree •disagree •agree •strongly agree
PD05a	This project has an integrated event-based schedule that is structured as a networked, multi-layered schedule of project tasks required to complete the work effort	•strongly disagree •disagree •agree •strongly agree
PD05b	This project has an integrated event-based schedule that contains a compilation of key technical accomplishments (e.g., a Systems Engineering Master Schedule)	•strongly disagree •disagree •agree •strongly agree
PD05c	This project has an integrated event-based schedule that references measurable criteria (usually contained in the Integrated Master Plan) required for successful completion of key technical accomplishments	•strongly disagree •disagree •agree •strongly agree
PD05d	This project has an integrated event-based schedule that is consistent with the WBS	•strongly disagree •disagree •agree •strongly agree

Survey Questions (Part 3)

ID	Question	Response range
PD05e	This project has an integrated event-based schedule that identifies the critical path of the program schedule	•strongly disagree •disagree •agree •strongly agree
PD06	This project has a plan or plans for the performance of technical reviews with defined entry and exit criteria throughout the life cycle of the project	•strongly disagree •disagree •agree •strongly agree
PD07	This project has a plan or plans that include details of the management of the integrated technical effort across the project (e.g., a Systems Engineering Management Plan or a Systems Engineering Plan)	•strongly disagree •disagree •agree •strongly agree
PD08	Those who perform systems engineering activities actively participate in the development and updates of the project planning	•strongly disagree •disagree •agree •strongly agree
PD09	Those who perform systems engineering activities actively participate in tracking/reporting of task progress	•strongly disagree •disagree •agree •strongly agree

SE Capability:
Requirements Development & Mgmt (REQ)





Relationship to project performance:	Moderately strong positive relationship

SE Capability

	Gamma	p	Lower: Min. Range	Lower: # Lo	Lower: # Med	Lower: # Hi	Lower: Max. Range	Moderate: Min. Range	Moderate: # Lo	Moderate: # Med	Moderate: # Hi	Moderate: Max. Range	Higher: Min. Range	Higher: # Lo	Higher: # Med	Higher: # Hi	Higher: Max. Range
REQ	33%	4.0%	1.0	44%	38%	18%	2.8	2.8	26%	53%	21%	3.4	3.4	27%	18%	55%	4.0

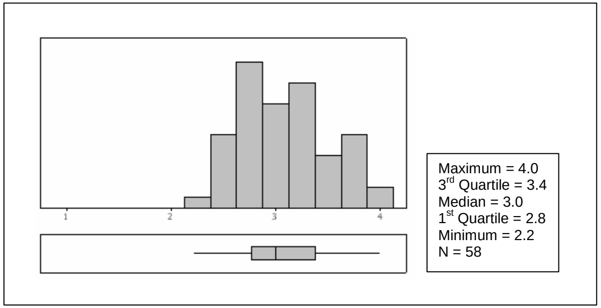
Survey Questions (Part 1)

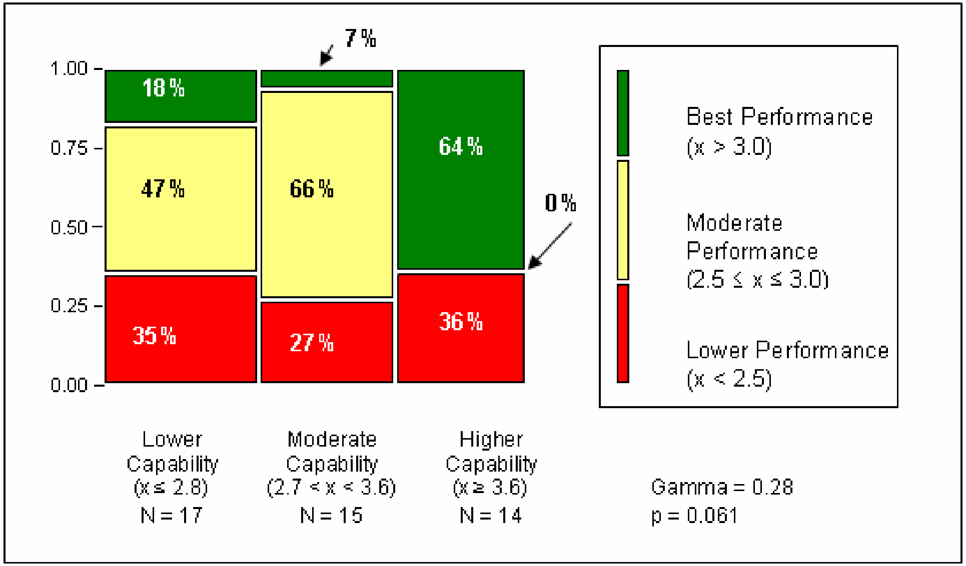
ID	Question	Response range
RD01a	This project maintains an up-to-date and accurate listing of all requirements specified by the customer, to include regulatory, statutory, and certification requirements	•strongly disagree •disagree •agree •strongly agree
RD01b	This project maintains an up-to-date and accurate listing of all requirements derived from those specified by the customer	•strongly disagree •disagree •agree •strongly agree
RD02	This project maintains up-to-date and accurate documentation clearly reflecting the hierarchical allocation of both customer and derived requirements to each element (subsystem, component, etc.) of the system in the configuration baselines	•strongly disagree •disagree •agree •strongly agree
RD03a	This project documents and maintains accurate and up-to-date descriptions of operational concepts and their associated scenarios	•strongly disagree •disagree •agree •strongly agree
RD03b	This project documents and maintains accurate and up-to-date descriptions of use cases (or their equivalent)	•strongly disagree •disagree •agree •strongly agree
RD03c	This project documents and maintains accurate and up-to-date descriptions of product installation, maintenance and support concepts	•strongly disagree •disagree •agree •strongly agree
RD04	This project has documented criteria for identifying authorized requirements providers to avoid requirements creep and volatility	•strongly disagree •disagree •agree •strongly agree

Survey Questions (Part 2)

ID	Question	Response range
RD05	This project has documented criteria (e.g., cost impact, schedule impact, authorization of source, contract scope, requirement quality) for evaluation and acceptance of requirements	•strongly disagree •disagree •agree •strongly agree
RD06	The requirements for this project are approved in a formal and documented manner by relevant stakeholders	•strongly disagree •disagree •agree •strongly agree
RD07	This project performs and documents requirements impact assessments for proposed requirements changes	•strongly disagree •disagree •agree •strongly agree
RD08	This project develops and documents project requirements based upon stakeholder needs, expectations, and constraints	•strongly disagree •disagree •agree •strongly agree
RD09	This project has an accurate and up-to-date requirements tracking system	•strongly disagree •disagree •agree •strongly agree
RD10a	For this project, the requirements documents are managed under a configuration control process	•strongly disagree •disagree •agree •strongly agree
RD10b	For this project, the requirements documents are accessible to all relevant project staff	•strongly disagree •disagree •agree •strongly agree

SE Capability:
Risk Management (RSKM)





Relationship to project performance:	Moderately strong positive relationship

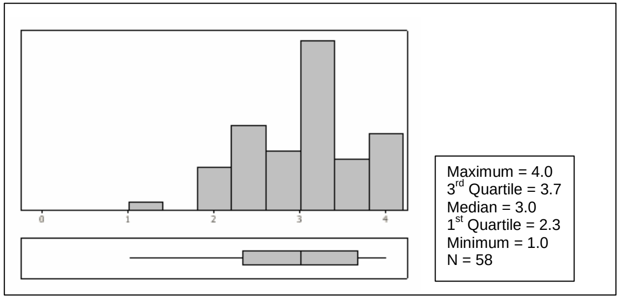
SE Capability

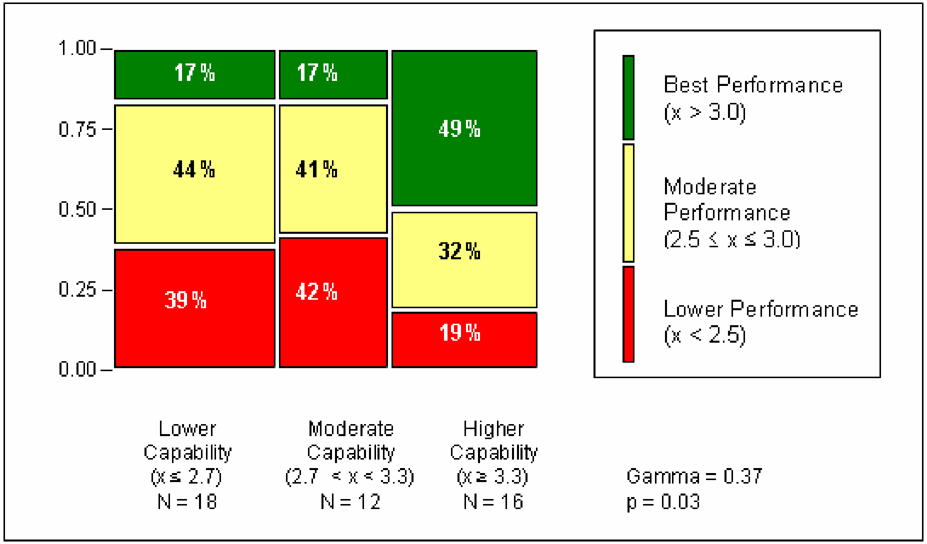
	Gamma	p	Lower Min. Range	Lower # Lo	Lower # Med	Lower # Hi	Lower Max. Range	Moderate Min. Range	Moderate # Lo	Moderate # Med	Moderate # Hi	Moderate Max. Range	Higher Min. Range	Higher # Lo	Higher # Med	Higher # Hi	Higher Max. Range
RSKM	28%	6.1%	1.0	35%	47%	18%	2.8	2.8	27%	66%	7%	3.6	3.6	36%	0%	64%	4.0

Survey Questions

ID	Question	Response range
PD11a	This project has a Risk Management process that creates and maintains an accurate and up-to-date list of risks affecting the project (e.g., risks to cost, risks to schedule, risks to performance)	•strongly disagree •disagree •agree •strongly agree
PD11b	This project has a Risk Management process that creates and maintains up-to-date documentation of risk mitigation plans and contingency plans for selected risks	•strongly disagree •disagree •agree •strongly agree
PD11c	This project has a Risk Management process that monitors and reports the status of risk mitigation activities and resources	•strongly disagree •disagree •agree •strongly agree
PD11d	This project has a Risk Management process that assesses risk against achievement of an event-based schedule	•strongly disagree •disagree •agree •strongly agree
PD12	This project's Risk Management process is integrated with program decision-making	•strongly disagree •disagree •agree •strongly agree

SE Capability:
Trade Studies (TRADE)





Relationship to project performance:	Moderately strong to strong positive relationship

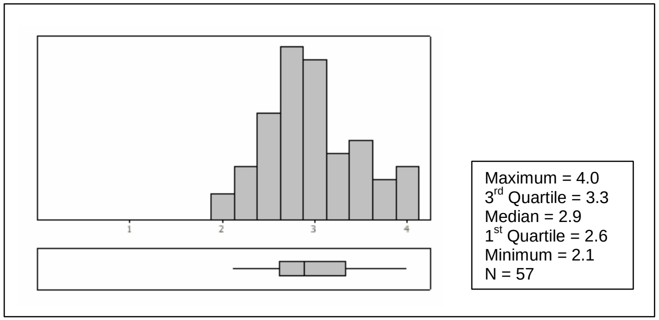
SE Capability

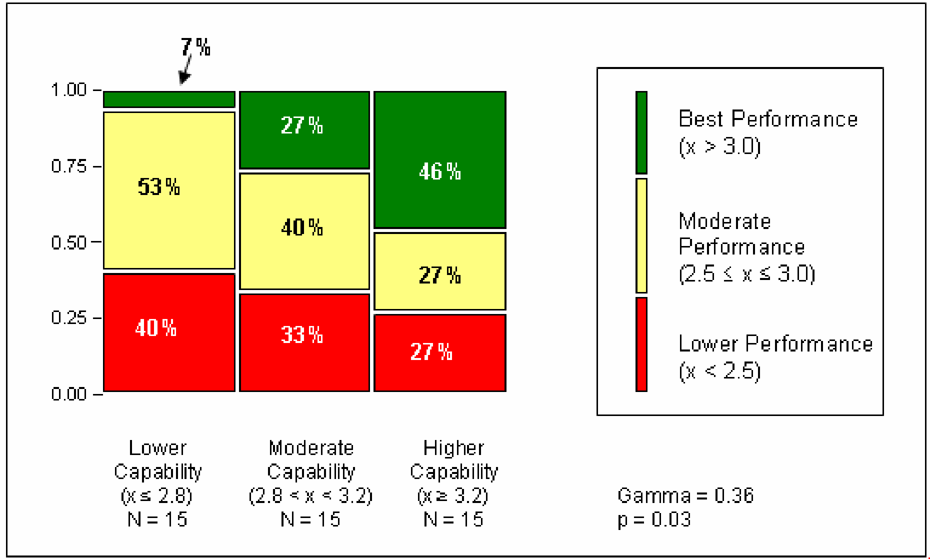
	Gamma	p	Lower Min. Range	Lower # Lo	Lower # Med	Lower # Hi	Lower Max. Range	Moderate Min. Range	Moderate # Lo	Moderate # Med	Moderate # Hi	Moderate Max. Range	Higher Min. Range	Higher # Lo	Higher # Med	Higher # Hi	Higher Max. Range
TRADE	37%	3.0%	1.0	39%	44%	17%	2.7	2.7	42%	41%	17%	3.3	3.3	19%	32%	49%	4.0

Survey Questions

ID	Question	Response range
RD11	Stakeholders impacted by trade studies are involved in the development and performance of those trade studies	•strongly disagree •disagree •agree •strongly agree
RD12	This project performs and documents trade studies between alternate solutions based upon definitive and documented selection criteria	•strongly disagree •disagree •agree •strongly agree
RD13	Documentation of trade studies is maintained in a defined repository and is accessible to all relevant project staff	•strongly disagree •disagree •agree •strongly agree

SE Capability:
Technical Solution (TS)





Note: TS is a composite measure equivalent to ARCH + TRADE.

Relationship to project performance:	Moderately strong positive relationship

SE Capability

			Lower					Moderate					Higher				
	Gamma	p	Min. Range	# Lo	# Med	# Hi	Max. Range	Min. Range	# Lo	# Med	# Hi	Max. Range	Min. Range	# Lo	# Med	# Hi	Max. Range
TS	36%	3.0%	1.0	40%	53%	7%	2.8	2.8	33%	40%	27%	3.2	3.2	27%	27%	46%	4.0

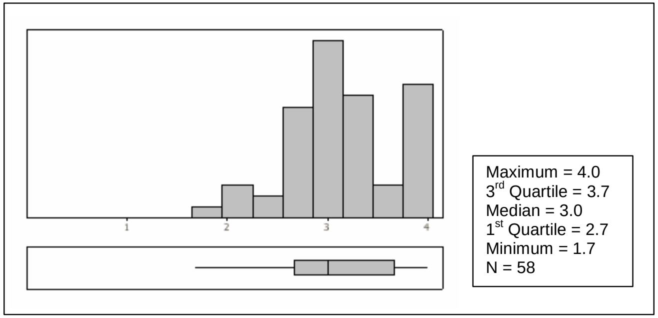
Survey Questions (Part 1)

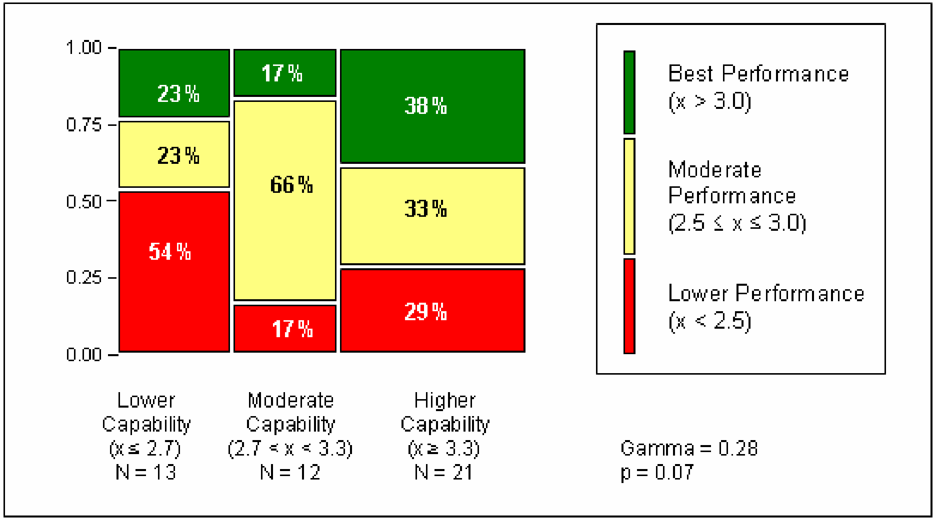
ID	Question	Response Range
RD11	Stakeholders impacted by trade studies are involved in the development and performance of those trade studies	•strongly disagree •disagree •agree •strongly agree
RD12	This project performs and documents trade studies between alternate solutions based upon definitive and documented selection criteria	•strongly disagree •disagree •agree •strongly agree
RD13	Documentation of trade studies is maintained in a defined repository and is accessible to all relevant project staff	•strongly disagree •disagree •agree •strongly agree
IF01	This project maintains accurate and up-to-date descriptions (e.g. interface control documents, models, etc.) defining interfaces in detail	•strongly disagree •disagree •agree •strongly agree
IF02	Interface definition descriptions are maintained in a designated location, under configuration management, and accessible to all who need them	•strongly disagree •disagree •agree •strongly agree

Survey Questions (Part 2)

ID	Question	Response Range
IF03a	For this project, the product high-level structure is documented, kept up to date, and managed under configuration control	•strongly disagree •disagree •agree •strongly agree
IF03b	For this project, the product high-level structure is documented using multiple views (e.g. functional views, module views, etc.)	•strongly disagree •disagree •agree •strongly agree
IF03c	For this project, the product high-level structure is accessible to all relevant project personnel	•strongly disagree •disagree •agree •strongly agree
IF04	This project has defined and documented guidelines for choosing COTS product components	•strongly disagree •disagree •agree •strongly agree

SE Capability: Validation (VAL)





Relationship to project performance:	Moderately strong positive relationship

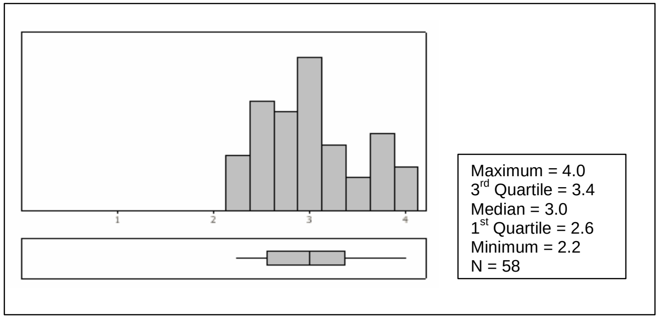
SE Capability

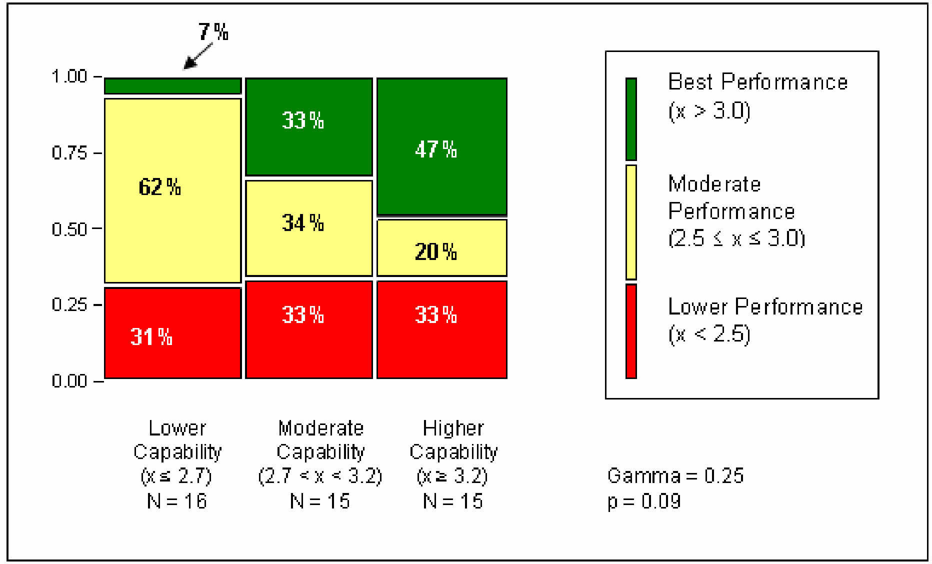
			Lower					Moderate					Higher				
	Gamma	p	Min. Range	# Lo	# Med	# Hi	Max. Range	Min. Range	# Lo	# Med	# Hi	Max. Range	Min. Range	# Lo	# Med	# Hi	Max. Range
VAL	28%	7.0%	1.0	54%	23%	23%	2.7	2.7	17%	66%	17%	3.3	3.3	29%	33%	38%	4.0

Survey Questions

ID	Question	Response Rate
V&V04a	This project has accurate and up-to-date documents defining the procedures used for the validation of systems and system elements	•strongly disagree •disagree •agree •strongly agree
V&V04b	This project has accurate and up-to-date documents defining acceptance criteria used for the validation of systems and system elements	•strongly disagree •disagree •agree •strongly agree
V&V05	This project maintains a listing of items managed under configuration control	•strongly disagree •disagree •agree •strongly agree

SE Capability: Verification (VER)





Relationship to project performance:	Moderately strong positive relationship

SE Capability

			Lower					Moderate					Higher				
	Gamma	p	Min. Range	# Lo	# Med	# Hi	Max. Range	Min. Range	# Lo	# Med	# Hi	Max. Range	Min. Range	# Lo	# Med	# Hi	Max. Range
VER	25%	9.0%	1.0	31%	62%	7%	2.7	2.7	33%	34%	33%	3.2	3.2	33%	20%	47%	4.0

Survey Questions (Part 1)

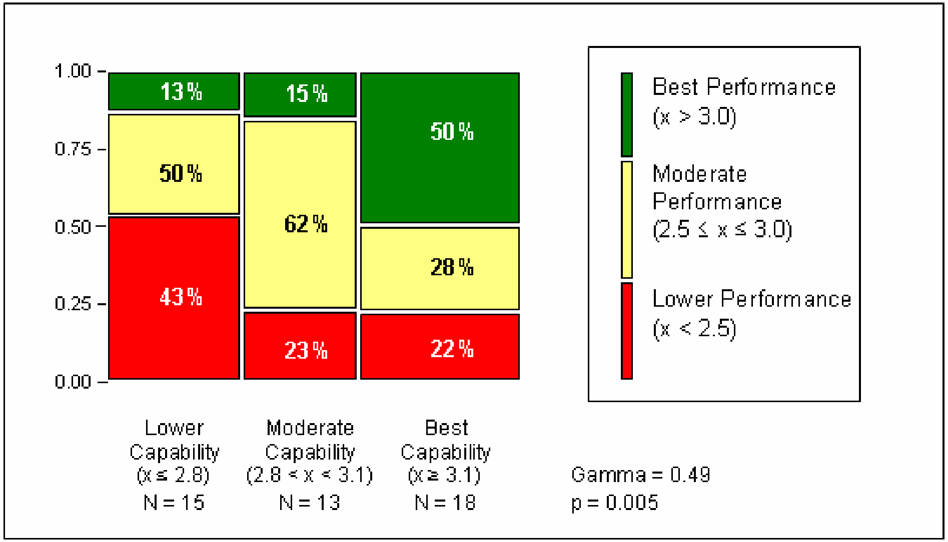
ID	Question	Response range
V&V01a	This project has accurate and up-to-date documents defining the procedures used for the test and verification of systems and system elements	•strongly disagree •disagree •agree •strongly agree
V&V01b	This project has accurate and up-to-date documents defining acceptance criteria used for the verification of systems and system elements	•strongly disagree •disagree •agree •strongly agree
V&V02a	This project has a documented and practiced review (e.g. peer reviews, design reviews, etc.) process that defines entry and exit criteria for work products	•strongly disagree •disagree •agree •strongly agree
V&V02b	This project has a documented and practiced review (e.g. peer reviews, design reviews, etc.) process that includes training requirements for the reviewers	•strongly disagree •disagree •agree •strongly agree
V&V02e	This project has a documented and practiced review (e.g. peer reviews, design reviews, etc.) process that addresses identified risks and risk mitigation activities during reviews	•strongly disagree •disagree •agree •strongly agree
V&V02f	This project has a documented and practiced review (e.g. peer reviews, design reviews, etc.) process that examines completeness of configuration baselines	•strongly disagree •disagree •agree •strongly agree

Survey Questions (Part 2)

ID	Question	Response range
V&V03	This project conducts non-advocate reviews (e.g. reviews by qualified personnel with no connection to or stake in the project) and documents results, issues, action items, risks, and risk mitigations	•strongly disagree •disagree •agree •strongly agree
V&V02c	This project has a documented and practiced review (e.g. peer reviews, design reviews, etc.) process that defines criteria for the selection of work products (e.g., requirements documents, test plans, system design documents, etc.) for review	•strongly disagree •disagree •agree •strongly agree
V&V02d	This project has a documented and practiced review (e.g. peer reviews, design reviews, etc.) process that tracks action items to closure	•strongly disagree •disagree •agree •strongly agree

SE Capability:
Combined Reqts+Tech Solution (REQ+TS)

(This is a higher order measure; see base measures for distribution)

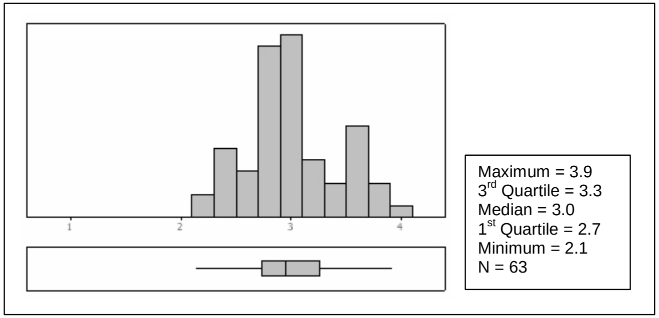


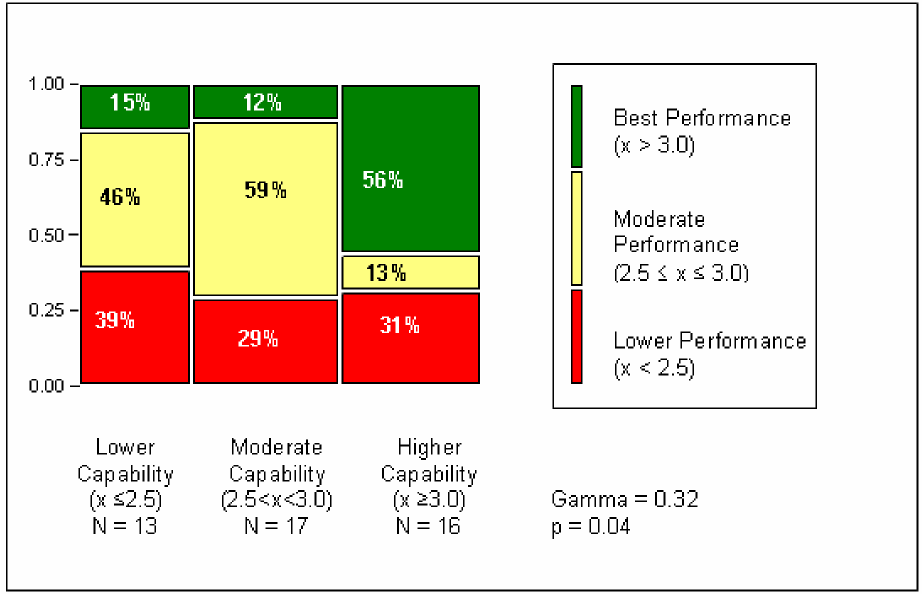
Relationship to project performance:	Strong positive relationship

SE Capability

	Gamma	p	Lower Min. Range	Lower # Lo	Lower # Med	Lower # Hi	Lower Max. Range	Moderate Min. Range	Moderate # Lo	Moderate # Med	Moderate # Hi	Moderate Max. Range	Higher Min. Range	Higher # Lo	Higher # Med	Higher # Hi	Higher Max. Range
REQ+TS	49%	0.5%	1.0	43%	50%	13%	2.8	2.8	23%	62%	15%	3.1	3.1	22%	28%	50%	4.0

SE Capability:
Total Systems Engineering Capability





Relationship to project performance:	Moderately strong positive relationship

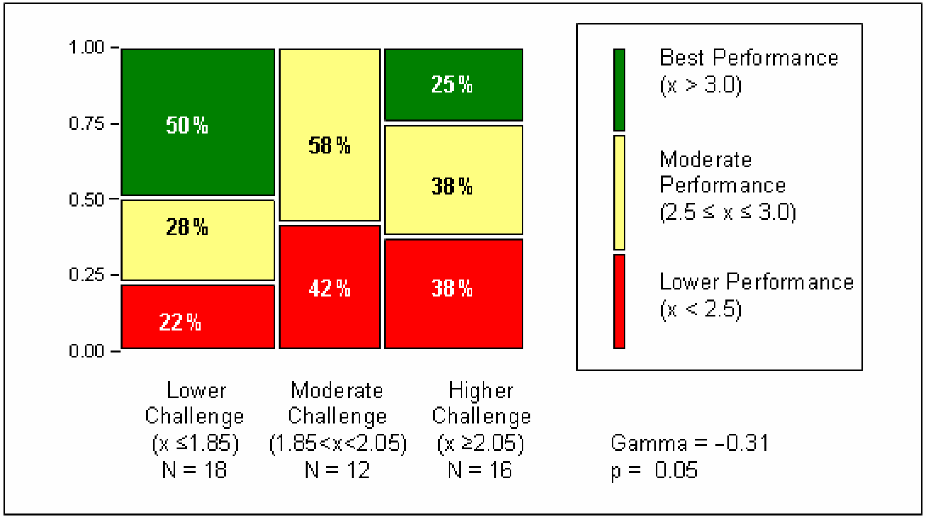
SE Capability

	Gamma	p	Lower Min. Range	Lower # Lo	Lower # Med	Lower # Hi	Lower Max. Range	Moderate Min. Range	Moderate # Lo	Moderate # Med	Moderate # Hi	Moderate Max. Range	Higher Min. Range	Higher # Lo	Higher # Med	Higher # Hi	Higher Max. Range
Overall SEC	32%	4.0%	1.0	39%	46%	15%	2.5	2.5	29%	59%	12%	3.0	3.0	31%	13%	56%	4.0

Project Challenge (PC)

Project challenge factors:

- •Life cycle phases
- •Project characteristics
  (e.g., size, effort, duration, volatility)
- •Technical complexity
- •Teaming relationships

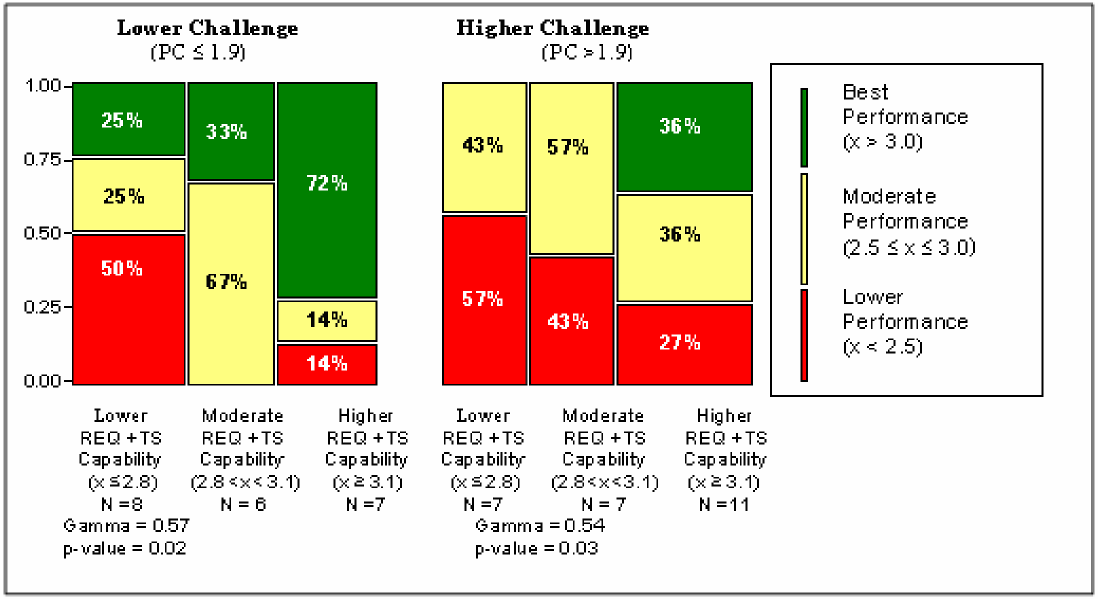


Relationship to project performance:	Moderately strong negative relationship

Project Challenge

	Gamma	p	Lower Min. Range	Lower # Lo	Lower # Med	Lower # Hi	Lower Max. Range	Moderate Min. Range	Moderate # Lo	Moderate # Med	Moderate # Hi	Moderate Max. Range	Higher Min. Range	Higher # Lo	Higher # Med	Higher # Hi	Higher Max. Range
PC	-31%	5.0%	1.0	22%	28%	50%	1.85	1.85	42%	58%	0%	2.05	2.05	38%	38%	25%	4.0

SE Capability:
Reqts+Tech Solution with Project Challenge

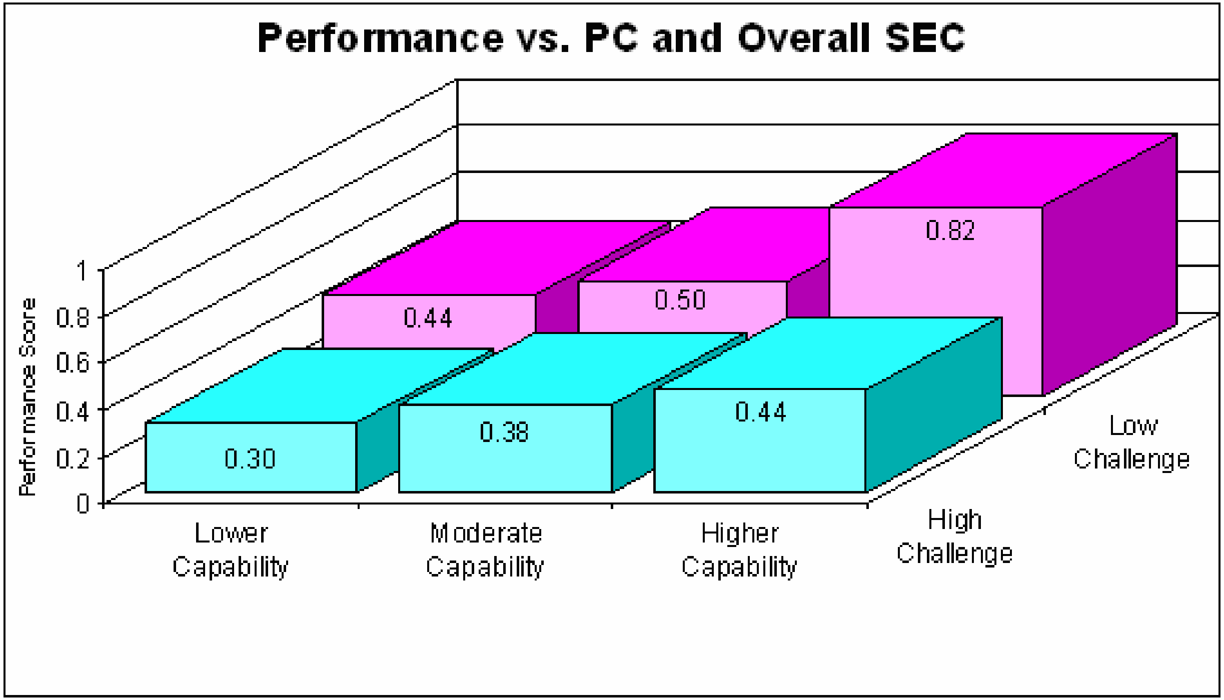


Relationship to project performance:	Very strong positive relationship

SE Capability + Project Challenge

	Gamma	p	Lower Min. Range	Lower # Lo	Lower # Med	Lower # Hi	Lower Max. Range	Moderate Min. Range	Moderate # Lo	Moderate # Med	Moderate # Hi	Moderate Max. Range	Higher Min. Range	Higher # Lo	Higher # Med	Higher # Hi	Higher Max. Range
REQ+TS+PC	63%	0.0%	1.0	67%	33%	0%	1.7	1.7	25%	45%	30%	2.3	2.3	14%	36%	50%	4.0

Relating Project Performance to Project Challenge and SE Capability

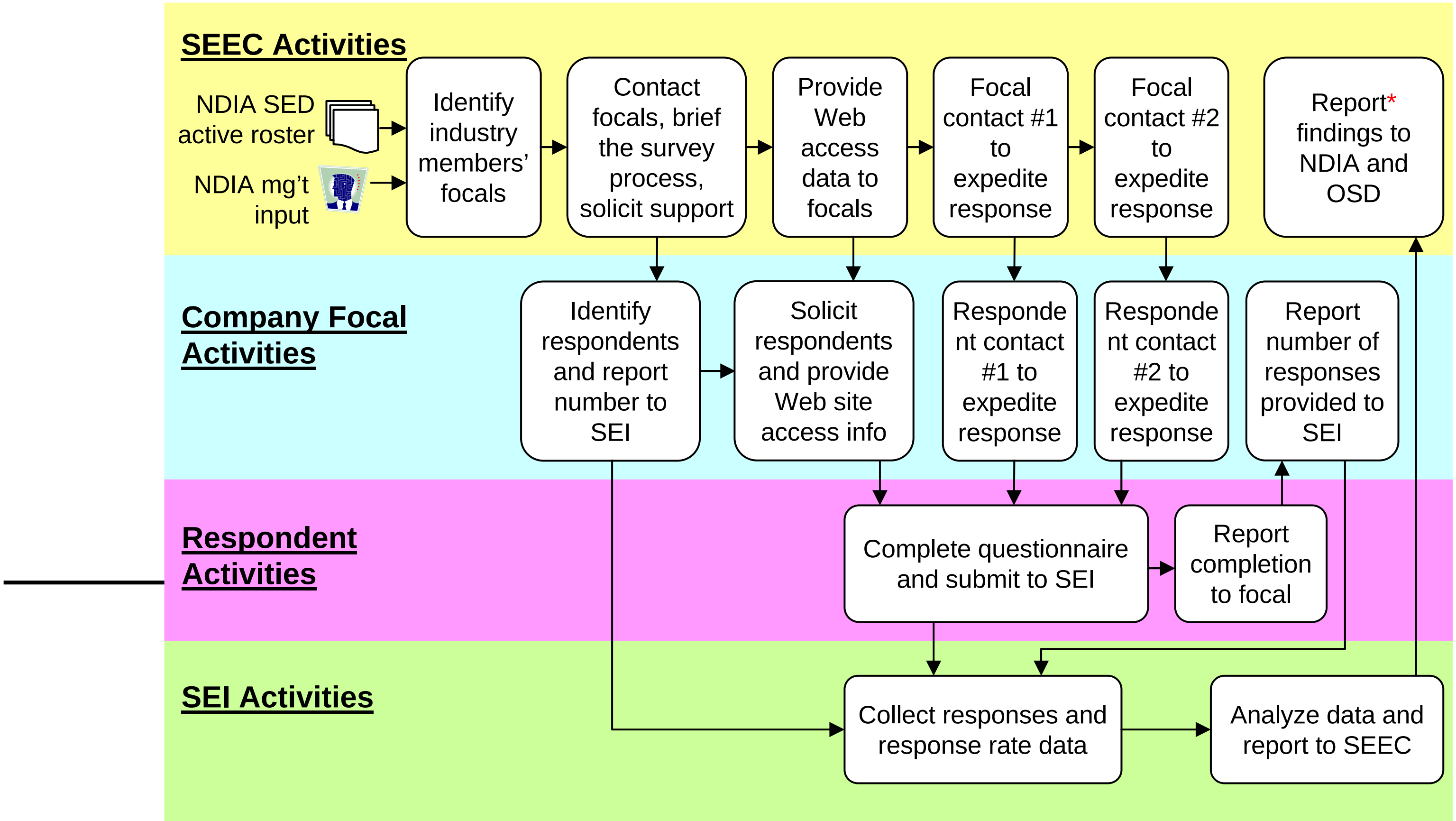


SE Effectiveness
Relationship of SEC to Performance

Supplier Systems Engineering Capability[1]	Relationship to Project Performance	Relationship (Gamma[2])	Section Reference
Project Planning	Weak positive relationship	+0.13	5.1.3.2
Project Monitoring and Control	Weak negative relationship	-0.13	5.1.3.3
Risk Management	Moderately strong positive relationship	+0.28	5.1.3.4
Requirements Development & Management	Moderately strong positive relationship	+0.33	5.1.3.5
Trade Studies	Strong positive relationship	+0.37	5.1.3.6
Product Architecture	Moderately strong to strong positive relationship	+0.40	5.1.3.7
Technical Solution	Moderately strong positive relationship	+0.36	5.1.3.8
Product Integration	Weak positive relationship	+0.21	5.1.3.9
Verification	Moderately strong positive relationship	+0.25	5.1.3.10
Validation	Moderately strong positive relationship	+0.28	5.1.3.11
Configuration Management	Weak positive correlation	+0.13	5.1.3.12
IPT-Related Capability	Moderately strong positive correlation	+0.34	5.1.3.1

SE Effectiveness

Methodology (In Detail)



SE Effectiveness

Methodology (Mathematical Statement)

$$\boldsymbol{Perf} = f\,(\boldsymbol{PC}, \boldsymbol{PE}, \boldsymbol{SEC}, \boldsymbol{AC})$$

***Perf* -** Project Performance
PC - Project Challenge
PE - Project Environment ***PE***
SEC - Systems Engineering Capability
AC - Acquirer Capability

Results

Summary of Relationships

Driving Factor	Relationship to Project Performance	
	Description	Γ
Requirements and Technical Solution Combined with Project Challenge	Very strong positive	+0.63
Combined Requirements and Technical Solution	Strong positive	+0.49
Product Architecture	Moderately strong to strong positive	+0.40
Trade Studies	Moderately strong to strong positive	+0.37
IPT-Related Capability	Moderately strong positive	+0.34
Technical Solution	Moderately strong positive	+0.36
Requirements Development and Management	Moderately strong positive	+0.33

Driving Factor	Relationship to Project Performance	
	Description	Γ
Total Systems Engineering Capability	Moderately strong positive	+0.32
Project Challenge	Moderately strong negative	-0.31
Validation	Moderately strong positive	+0.28
Risk Management	Moderately strong positive	+0.28
Verification	Moderately strong positive	+0.25
Product Integration	Weak positive	+0.21
Project Planning	Weak positive	+0.13
Configuration Management	Weak positive	+0.13
Process Improvement	Weak positive	+0.05
Project Monitoring and Control	Weak negative	-0.13

Realization of Systems Engineering For the Future

10th Annual NDIA
Systems Engineering Conference
22-25 Oct 2007
Ms. Karen B. Bausman
Senior Systems Engineer
USAF Center for Systems Engineering
Karen.bausman@afit.edu
937-255-3355 ext 3331

Overview

- Background
- Systems Engineering Challenges
- Key Enablers
- The Way Ahead

Background

- Five Years Ago Revitalization of Systems Engineering Established

- Current Feedback Indicates this has "…not eliminated cost and schedule problems for major weapons development programs."*

- Shortages in Qualified Systems Engineers

- We are NOT meeting the Challenges of Current Systems or Projected Systems of the Future

* GAO Report "Major Weapon Systems Continue to Experience Cost and Schedule Problems Under DoD's Revised Policy", April 2006.

Systems Engineering Challenges

- Inconsistent Application of SE
- Need More Qualified SE
- Product Complexity/Product Control
- Poor Requirements Up Front
- Where Does Sustainment Fit In?
- Loss of Historical Information
- Systems Engineering Research

Inconsistent Application of SE

- Multiple Definitions of SE Exist
- Harmonization of SE Stds is Not Occurring “Fast” Enough
- SE Stds’ Architecture needed to see Big Picture
  - Consistent Definition at Beginner/Intermediate/Expert Levels
  - Simple to Complex Program Guidance
  - Domain Guidance
- Agreement on SE Processes Definitions Needed by
  - Industry Associations (INCOSE, NDIA, IEEE, GEIA)
  - Standard Committees (ISO, EIA, IEEE)
  - Other Stakeholders (OSD, Academia, SEI)
- Update and Implementation of SE Continual Improvement Methodologies to Improve Consistency

Standardized Definition of SE Processes is Key!!

Need More Qualified SE

- Current Activities Ineffective in Impacting Issues*
- Need Innovative Approach
  - Identify Potential Early and Encourage Development
  - Introduce Systems Thinking Early**
    1. Thinking Broadly, Big Picture
    2. Curiosity, Questioning
    3. Open-mindedness
    4. Strong Interpersonal Skills
    5. Thinking Outside the Box
    6. Strong Communication Skills
    7. Tolerance for Uncertainty
    8. Multi-taskers
  - Create Choices In Undergraduate Programs
- Emphasize SE Development in Workforce
  - Identify SE Core Competencies and Performance Accountability
  - Create Programs to Develop High Potential Employees
    - Potential Graduate Degrees
    - Target Life and Work Experiences Through OJT

Innovative Academic Roadmap Needed Now

* NDIA "Top Five SE Issues within DoD and Defense Industry", July 2006
** Davidz, "Enabling Systems Thinking to Accelerate the Development of Senior SE", 2006

Product Complexity/Product Control

- Complexity of the Product is Inverse to Ease of Control
  - As Systems Become More Complex their Development is Harder to Control

- Need to Identify SE Tools to Simplify the Control Aspects of Future Programs

- Technical Management Processes must keep Pace with Increasing Complexity

Collaborative Environments must be Integrated Through-out Systems Life

Poor Requirements Up Front

- Not a New Problem*
- Need Cause and Effect Analysis to Identify all Pitfalls
- Need Design Solution Accepted by All with Recommended Changes to Existing Policies and Procedures
- Need Methods to Highlight Risk and Complexity
- No Connection Between Identifiers/Developers of Capability AND the Cost/Schedule Estimators UP FRONT

Bridges of Accountability
Between Technical and Business

* NDIA “Top Five SE Issues within DoD and Defense Industry”, 2004 and 2006.

Where Does Sustainment Fit In?

- Build Now - Fix Later Never a Planned Strategy
  - Not Efficient Enough for the Future
  - Future Reduction of Personnel and
  - Lower Operating/Sustaining Budgets Expected

- Information on SE Sustainment Application Needed
  - Guidance for SE Sustainment Monitor Activities
  - Guidance for SE Sustainment Modification Activities
  - Guidance for SE Concept/Technology/Development Activities Focused on Sustainment

- Change Title and Requirement for IOC to Initial Operational/Support Capability (IOSC)
  - Elevate to Milestone D

Special Emphasis on Sustainment from Start
Resurgence of Acquisition Logistics

Loss of Historical Information

- New Information Management Process in ISO 15288
  - Information stored in System Electronic Database

- Adapt Mindset of Reuse to Other SE Issues
  - Decision Analysis & Results Data
  - Decisions and Paths Followed
  - Methods Used Lessons Learned
  - Time Tables of Changes With Initiator Identified

- Program Linkage Maintained Throughout Lifecycle

System Electronic Database Transfers With Program/Engineering Responsibility through System Life

* DoD 5000.1 Enclosure 1 Additional Policy E1.18 “Products, Services and Technologies”, last updated Feb 2007.

Systems Engineering Research

SE Research* will Help get us there
We Need Champions!

- Complexity/Risk Impacts Pre Program
- Expansion of SE Indicators, Incorporation of Risk/Complexity into EVMS
- Early Incorporation of Technology/Planning
- SE Friendly Contracting Solutions
- Evolution of SE Process Areas
- M&S Tools and Management Environments (Toolsets)
- Domain Specific Complexity Studies (e.g. SW Measures Other than SLOC)

* Castellano Briefing, “Emerging Research Ideas Stemming from Systemic Analysis of DoD Programs”, June 2007 And Masterson Briefing, “Systems Engineering Research Needs”, July 2007

SE Challenges & Recommendations Summary

Inconsistent Application of SE	Agreed Standardized SE Definition
Need More Qualified SE	Innovative Academic Approach
Product Complexity/Product Control	Collaborative Environment
Poor Requirements Up Front	Bridges of Accountability
Where Does Sustainment Fit?	Focus on Sustainment & Acquisition Logistics
Loss of Historical Data	Electronic System Database
Systems Engineering Research	Champions Needed

Key Enablers

- Systems Thinking for all Functionals to:
  - Learn Technical Basics of System, Participate in Risk Assessments and Bring Their Strategies to Table to Develop Overall Program Acquisition Strategy
- Institute an Systems Electronic Database for Life
  - Decision Analysis and Results; Risk Assessment and Measures,
  - Functional Strategies, SAMP, ASP, RFP, SSP
  - All Functionals Identify and Share Changes to Program Baselines
- Discipline, Discipline, Discipline…

Systems Engineering is NOT Just for Engineers!!!

The Way Ahead

1. Complexity will Increase in Future Systems

2. An Integrated and Coordinated Effort is Needed Now

3. First Step is to Get SE Processes Defined/Accepted

4. Second Step is to Hold a SE Vision Forum/Workshop
   - Attended by All SE Associated Organizations
   - Purpose to Define the Way
   - Generate and Execute A Realization Plan for Global Systems Engineering for the Future

Volunteer to Participate so You Can be Heard!

Establish M&S-related Guidelines for Solicitations, Source Selections, and Contracting

Acquisition Business Plan

Action 1-5

Tasking

Establish M&S-related guidelines for solicitations, source selections, and contracting.

RATIONALE: There are insufficient guidelines regarding contracting for M&S and the data it needs or produces. Acquisition programs often leave M&S planning, use, and ownership to prime contractors. Government organizations are often unaware of contractor attributes that are indicators of M&S capability maturity and are, therefore, useful criteria in evaluating proposals. Rarely is early consideration and contractual direction specifically intended to provide access to, or reuse of, models and data across the life-cycle.

DISCUSSION: The recommended RFP language and contract provisions should address M&S strategy; representation requirements; M&S tool sources; ownership and maintenance; data sources and rights; VV&A; user support; access control; and metrics and documentation requirements, all across the system life-cycle. The source selection criteria guidance should address those contractor attributes that have a direct relationship to successful M&S use.

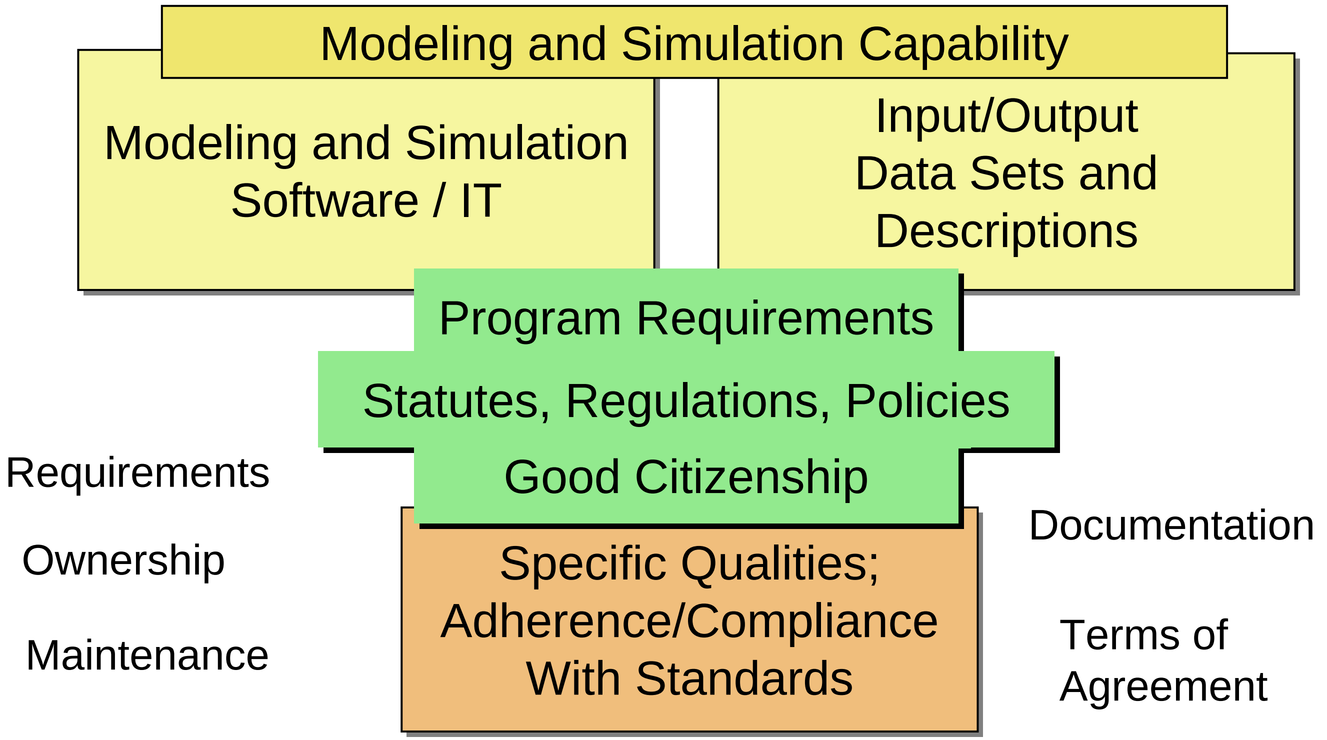
LEAD: USD(AT&L)/DS

SUPPORT: USD(AT&L)/ Defense Procurement and Acquisition Policy (DPAP), DOT&E and Components

PRODUCTS: Sample language and suggested criteria in DAG. Updates to Federal Acquisition Regulations (FAR) as appropriate. Contract Data Requirements List (CDRL) or a family of CDRLs listing the M&S requirements for an RFP.

Decomposing the Problem

"The PM shall plan for M&S throughout the acquisition life cycle. The PM shall identify and fund required M&S resources early in the life cycle" – DoDI 5000.2 E5.1.10



"The SOW should specify in clear, understandable terms the work to be done in developing or producing the goods to be delivered or services to be performed by a contractor. Preparation of an effective SOW requires both an understanding of the goods or services that are needed to satisfy a particular requirement and an ability to define what is required in specific, performance-based, quantitative terms." – MIL-HDBK-245D

Action Deliverables

- Objective: Help the Program Manager plan for, request and get what they need
  - Raise questions for consideration
  - Advise on appropriateness of request and completeness and quality of response
  - Provide boilerplate and “fill in the blank” RFP and contract language
  - Recommend ways to apply guidance and language to align THEIR acquisition/procurement documentation with a program Life-cycle and DoD Enterprise view

- Forms
  - M&S Acquisition Guide. 8-10 pages providing questions, measures, langauge and application principles for their consideration
    - Managed AT&L publication?

  - Influence. DoD and component acquisition and procurement regulations, policies and guidance.
    - FAR; DFARS; DoDD 5000.1; DoDI 5000.2; DoD component policy and guidance
    - *Defense Acquisition Guidebook*
    - *Guide for Integrating Systems Engineering into DoD Acquisition Contracts*

  - Continuous Improvement. Establish a process to collect lessons learned, update M&S Acquisition Guide and target reviews and updates of DoD regs, policies and guidance

Modeling and Simulation

MODEL: The knowledge and understanding that the scientist has about the world is often represented in the form of models. … *A model is a representation containing the essential structure of some object or event in the real world.* – From Introductory Statistics: Concepts, Models, and Applications by David W. Stockburger

predict

understand

evaluate

SIMULATION: The process of designing a model of a real system and conducting experiments with this model for the purpose either of understanding the behavior of the system or of evaluating various strategies (within the limits imposed by a criterion or set of criteria) for the operation of the system." from Introduction to the Art and Science of Simulation; 1998 Winter Simulation Conference 1998. R.E. Shannon.

executable Knowledge

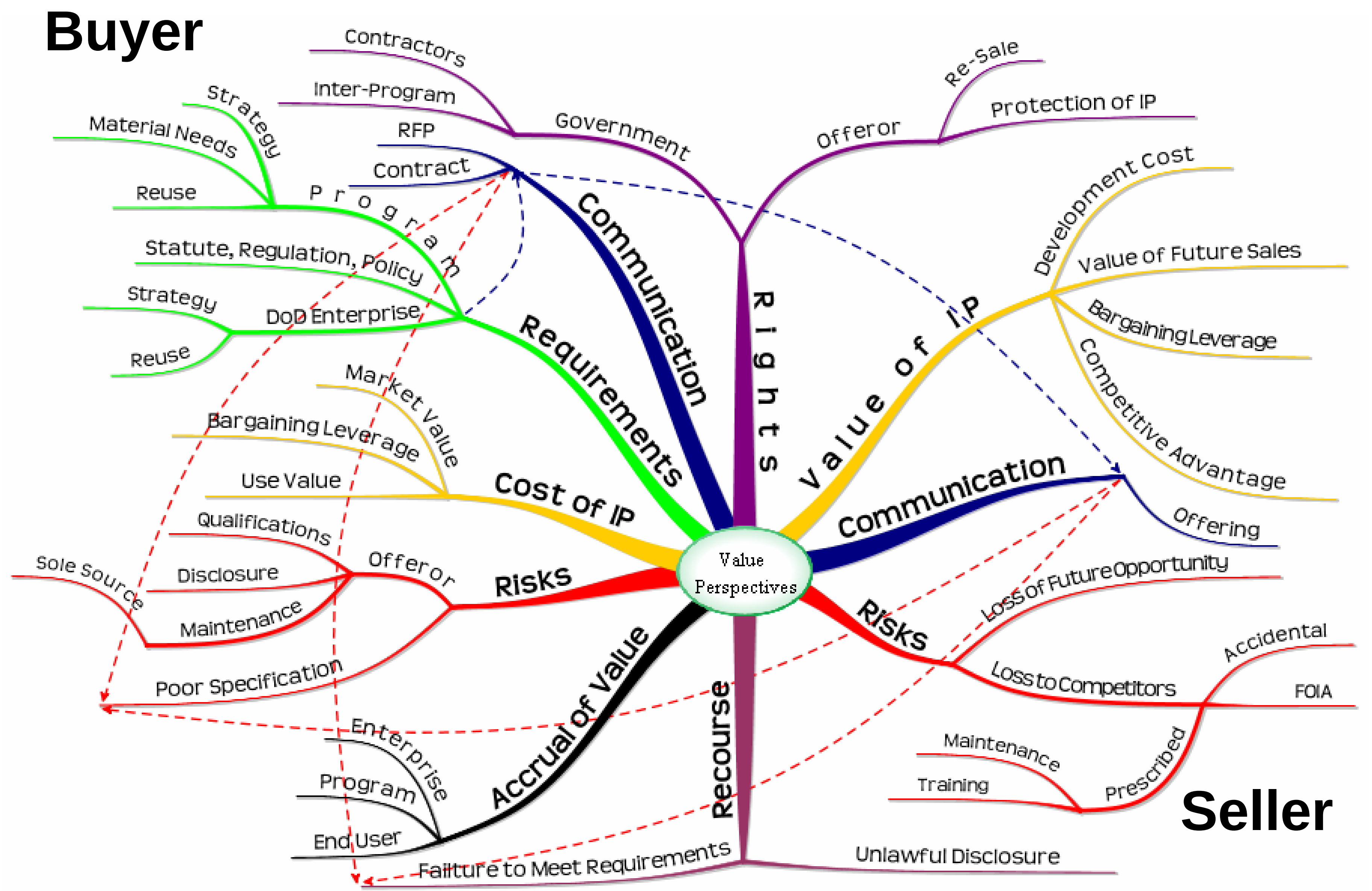
MODEL: A representation of a system that allows for investigation of the properties of the system and, in some cases, prediction of future outcomes. Models are often used in quantitative analysis and technical analysis, and sometimes also used in fundamental analysis. – From "InvestorWords"

a way of thinking and reasoning about systems

The Essence of Intellectual Property

Essential structure

Value Perspectives



Other Considerations for M&S Acquisition

- Have a Rigorous M&S Planning Process
- Have an DoD Enterprise/Life-cycle Perspective
  - Discovery, Access, Interoperability, Reuse
- Have a VV&A plan

- Seek to leverage the best use of M&S capabilities from industry and government
  - Avoid building new capability when existing assets can be used
  - Strongly consider COTS solutions; resist temptation to favor custom solutions
- Seek to maximize value for the government
  - Understand market value of proposed IP
  - Maximize bargaining leverage by identifying requirements in the competition phase.
  - Be explicit about minimizing risk of exposure of IP
- Understand time-dependence of need
- Consider DoD Enterprise and Life-cycle Issues
  - M&S Strategy / Vision
  - Reuse and interoperability standards.
  - Assure M&S and associated data are available for other users throughout the system's life-cycle.
- Protect proprietary and intellectual property rights of M&S developers.

Statute, Regulation, Policy (e.g.)

- Title 5 U.S. Code Section 552; “Public information; agency rules, opinions, orders, records, and proceedings” -- FOIA
- Title 10 U.S. Code Chapter 137; “Procurement Generally”
- Title 10 U.S. Code Chapter 140; “Procurement of Commercial Items”
- Title 10 U.S. Code Chapter 141; “Miscellaneous Procurement Provisions”
- Title 18 U.S. Code; “Crimes and Criminal Procedures” – Trade Secrets Act, Economic Espionage Act
- Title 15 U.S. Code; “Commerce and Trade”
- Title 17 U.S. Code; “Copyrights”
- Title 35 U.S. Code; “Patents”
- Title 41 U.S. Code; “Public Contracts”
- Uniform Trade Secrets Act (compilation of State laws)

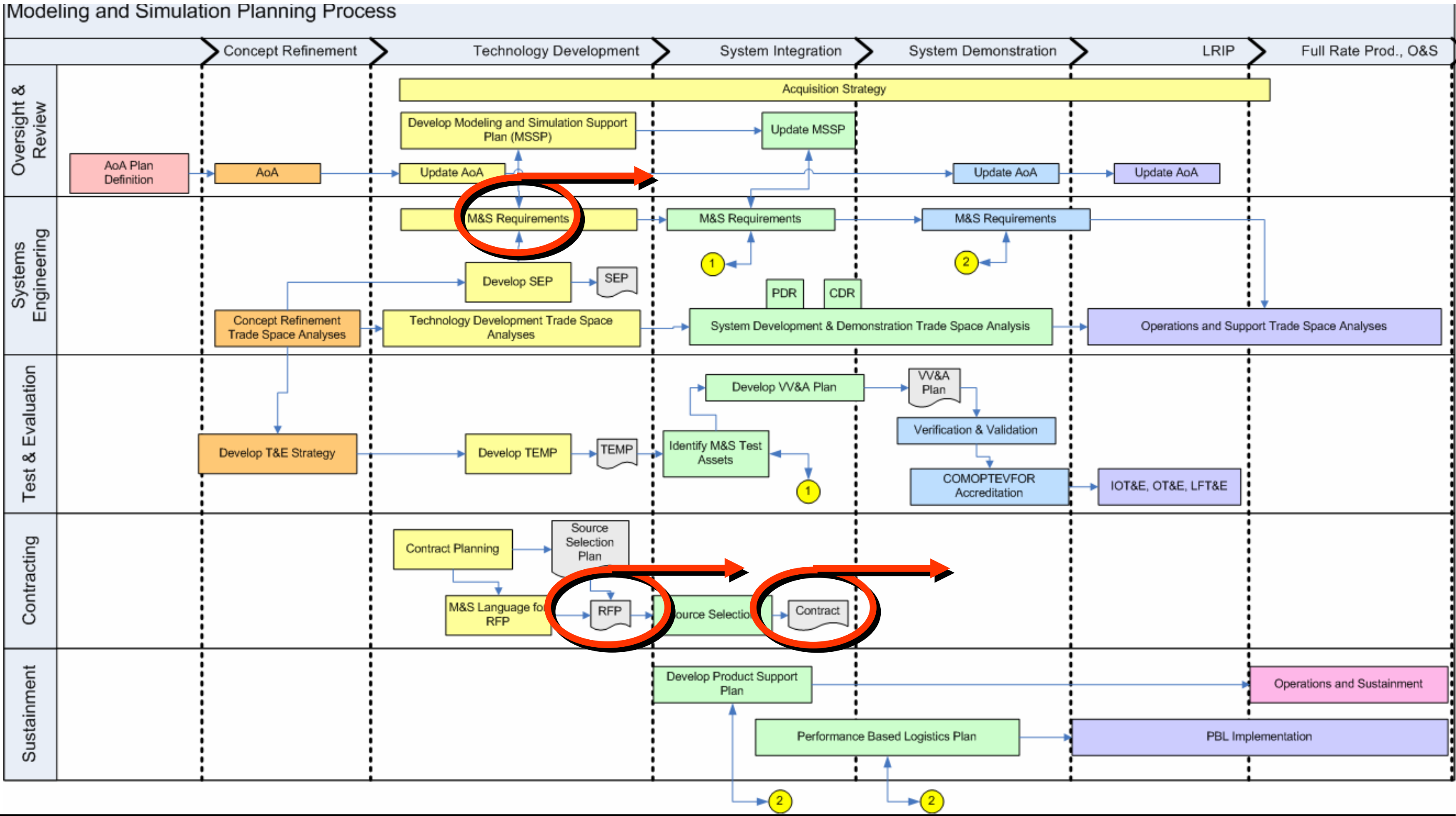
- Federal Acquisition Regulation (FAR)
- Defense Federal Acquisition Regulation Supplement (DFARS)
- International Traffic in Arms Regulations (ITAR)

- DoD Instruction 5000.2, “Operation of the Defense Acquisition System,” May 12, 2003.
- DoD Directive 8000.1, “Management of DoD Information Resources and Technology,” February 27, 2002.
- DoD Directive 8320.2, “"Data Sharing in a Net-Centric Department of Defense", December 2, 2004.
- DoD Instruction 5000.61, "DoD Modeling and Simulation (M&S) Verification, Validation, and Accreditation (VV&A)," May 13, 2003.
- SECNAV Instruction 5200.40, “Verification, Validation and Accreditation (VV&A) of Models and Simulations,” April 19, 1999.
- COMOPTEVFORINST 5000.1, “Use of Modeling and Simulation (M&S) in Operational Test (OT),” September 9, 2004.

- MIL-HDBK-245D, “DoD Handbook for Preparation of Statement of Work,” April 3, 1996.
- MIL-HDBK-61A(SE), “Configuration Management Guidance,” February 7, 2001.
- DoD VV&A Recommended Practices Guide, 2004.
- DoD 5000.59-M, “DoD Modeling and Simulation Glossary”, Jan 1998.

DRAFT

A Planned, DoD Enterprise/Life-cycle Commitment



RFP and Contracting Guidance has Little Value Without an M&S Plan

Proposed Considerations for RFP

- What New Modeling and Simulation Capabilities are Required?
  - How will the capabilities be used?
- Can the details of the requirement be clearly articulated in the RFP?
- Are there existing assets, currently available to the government, that can be applied to all or part of the requirement?
  - Appropriate pedigree
  - Appropriate for use
- What are the applicable model parameters, standards, interfaces, interoperability, and output requirements?
  - Alignment with Program and DoD Enterprise Goals
- What level of rights to the input/output data be required?
  - Access, Publish and Modify
  - Consider fixed-price options to purchase data rights downstream

Proposed Source Selection Considerations

- Technical
  - Feasibility of Proposed Solution
  - Availability of Required Data
- Value
  - Cost v. Benefit
  - Risk
- Spirit and Letter of the RFP
  - Meets Requirements
  - Meet Demands of Program and DoD Enterprise Strategy
  - Fitness for Use
  - Pedigree
  - Adherence to standards or provide reasonable argument for exemption
- Life-cycle Implications
  - Use Costs
    - Operations
    - Maintenance
    - License fees
  - Continued Support – Commitment to Sole Source?
- Offeror Qualifications
  - Documented systems-engineering process
  - Existing information sharing infrastructure
  - Successful experience using a wide of models and simulations
  - Successful application and demonstration of M&S interoperability and reuse standards
  - Documented VV&A process
  - Staff with documented M&S expertise
- Data Rights
  - Access to required input and output data.
  - Rights to use, publish and modify data as required
  - Are there fixed-price options for purchasing data rights later in the acquisition process?

Example Contract Language / Standard Clauses

- Rights in non-Commercial Software and Documentation (from DFARS)
- Rights in Technical Data – Non-Commercial (from DFARS)
- Quality Assurance (from clauses to sub-contractors to Boeing working NASA ISS)
- Software Management (from FCS)
- Data Formats; Data Content; Data Procedures (from U.S. Army Corps of Engineers – CADD)
- Offeror Qualifications (from Space Based Radar Task Order)
- NAVSEA SEAPORT-e
  - **Modeling, Simulation, Stimulation, and Analysis Support**
  - This functional area consists of the application of a standardized, rigorous, structured methodology to create and validate a physical, mathematical, or otherwise logical representation of a system, entity, phenomenon, or process. The functional area involves the use of models, including emulators, prototypes, simulators, and stimulators, either statically or over time, to develop data as a basis for making managerial, technical, strategic, or tactical decisions.

Summary

- Have a Rigorous M&S Planning Process and Documented Plan
  - VV&A Plan
  - Configuration Management Plan
  - Reference document in RFP and Contract
- Have an DoD Enterprise/Life-cycle Perspective
  - Discovery, Access, Interoperability, Reuse

- Next Steps
  - Continue to refine guidance/considerations
  - Review existing RFPs, Contracts, etc
  - Socialize and with Industry and Government Players
    - Technical Personnel
    - Contracts Personnel
    - Legal Personnel
  - Publish <u>M&S Acquisition Guide</u>
  - Develop plan to influence DoD and component regulations, policies and guidance
  - Establish Continuous Improvement Process

Example Proposed Contracting Language Considerations

The Contractor Shall:

- Develop, update and maintain M&S capability in compliance to a documented configuration management process.
- Describe his use of M&S throughout the system's lifecycle as an integral part of the Systems Engineering Plan.
- Develop, implement, and update M&S planning describing the contractor's use of M&S in the development of the system as an integral part of the Systems Engineering Plan.
- Collaborate with the government to develop a system model using architectural modeling tools in order to achieve mutual understanding of the system under development.
- Perform VV&A of modeling and simulation capabilities consistent with risk and DoD M&S VV&A Instruction 5000.61.
- Develop, and make accessible to the government an virtual representation of its system in the form of a model or simulation.
- Include in its participation in the required program reviews, performance of the system under development using simulations demonstrations with M&S developed by the contractor.

Modeling and Simulation Resource Reuse Business Model

Dennis P. Shea

Outline

- Problem statement
  - Barriers to reuse
  - Repositories as necessary but insufficient incentives
  - On the need for an M&S resource reuse business model
- Framework of a business model
- Focus areas
  - Laws and policies affecting intellectual property
  - Extending Tech Data rights to M&S resources
  - Mechanisms to support intra-government transactions
  - Measures to encourage open-source software
  - Improved discovery and distribution tools

The Problem:
Inefficient Use of M&S Resources

Few M&S resources are *re*used – either during a single program's lifecycle or across acquisition programs.

Tools	**Data**	**Environment**	
Models	Input datasets	Architectures	Network resources
Simulations	Scenarios	Interfaces	SME expertise
Federations	Threat data Algorithms	Protocols	
Utilities (post-Processors)	Environmental info	VV&A templates	

Absence of incentives for M&S managers and developers is a contributing factor.

Reusable M&S resources generally contain *valuable* intellectual property

- **Intellectual property refers to *creations of the mind*: inventions, literary and artistic works, and symbols, names, and images used in commerce.**
  - **In M&S the IP is often encapsulated in the source code and data sets**
- **DOD's access to M&S IP developed under contract is governed by both copyright law, patent law, and the procurement regulations contained in the DFARS**
  - **These laws affect the Government's ability to use, reproduce, modify, and release the resource to one or more potential users**
- **Control of IP is determined, in part, by who funded development**
  - **Government, Industry, or Mixed**
  - **But formal title is generally retained by the contractor-developer regardless of funding source**
  - **DoD acquisitions that involve a mix of government and IRAD funded technologies pose a challenge in determining control "rights"**

Barriers to M&S Resource Reuse

- Users lack awareness of reusable resources
- Insufficient details about reusable resources
- Hard to assess the true capabilities and limitations of existing resources
- Resources not in a form suitable for reuse
- Users lack trust in resources developed by others/ NIH
- Model is available but not the data
- M&S components don't work well together
- Repositories are incomplete and not current
- Little insight into how resources have been used in the past, including successfully and failures
- Difficult to access the actual resource
- Difficult to adapt existing resources to new problems
- No mechanism to compensate developer for resource investment and guidance on use
- No mechanism to protect developer from mischievous uses

M&S repositories, registries, etc. can be critical enablers

CNA

If they …

- Identify items that conform to quality standards and list pedigree
- Use a comprehensive, consistent, and well-structured taxonomy
- Include revisions, maintenance, and needed taxonomy updates
- Provide meta-data which includes semantics descriptors
- Include user-friendly search methods
- Are adequately funded / supported
  -- including staff to match users with resources
- Require security to control access, but not onerous security
- Include motivation to resource providers to populate and update

However, …

Improved M&S repositories could overcome some barriers

- **Users lack awareness of reusable resources**
- **Insufficient details about reusable resources**
- **Hard to assess the true capabilities and limitations of existing resources**
- Resources not in a form suitable for reuse
- Users lack trust in resources developed by others/ NIH
- Model is available but not the data
- M&S components don’t work well together
- **Repositories are incomplete and not current**
- **Little insight into how resources have been used in the past, including successfully and failures**
- Difficult to access the actual resource
- Difficult to adapt existing resources to new problems
- No mechanism to compensate developer for resource investment and guidance on use
- No mechanism to protect developer from mischievous uses

But repositories alone are insufficient to motivate reuse:

CNA

- Without incentives to populate, repositories will not include a comprehensive set of available resources
- Existing resources require additional work to adapt to new problems and support to guide their application
- Repositories often don’t facilitate the transaction to obtain the actual resource
- Repositories don’t protect the original developer from resource misuse by new users

Project objective

- Develop an economic business model that will make the reuse of M&S resources an attractive option for both consumers and providers of these resources
  - Identify incentives for consumers and providers
  - Establish how the transactions will occur
  - Identify funding and procurement policies and legislation that will need to be changed to put the reuse model into practice

Project results

CNA

A business model would help to

- Promote competition in the market for M&S assets by allowing for appropriate access to resources owned or controlled by DoD
- Ensure that the producers of M&S assets receive a fair return on their investments
- Create an IT environment that breaks down barriers to collaboration, teamwork, NIH, … and encourages a longer-term planning horizon.

Business Model Elements

A business model would describe the

- Value to M&S consumers produced by the ability to access and reuse M&S resources;
- The reciprocal value to M&S producers through transactions that result in the reuse of their resources;
- The capabilities, partners, and business processes required to create and deliver this value;
- The motivation, compensation principles, and policy necessary to sustain a mutually beneficial relationship between these entities

M&S Resource Reuse Business Model

CNA

IP Suppliers & Support Infrastructure

Partner network
- Gov't agencies
- Labs
- Industry
- International

Core capabilities
- H/W & S/W
- System information
- Org & Op Knowledge
- Conceptual models

Value activities
- Develop
- Test
- Validate
- Prototype

Value Proposition
- Savings (time/$$)
- Authoritative
- Joint context
- Interoperability

Customer

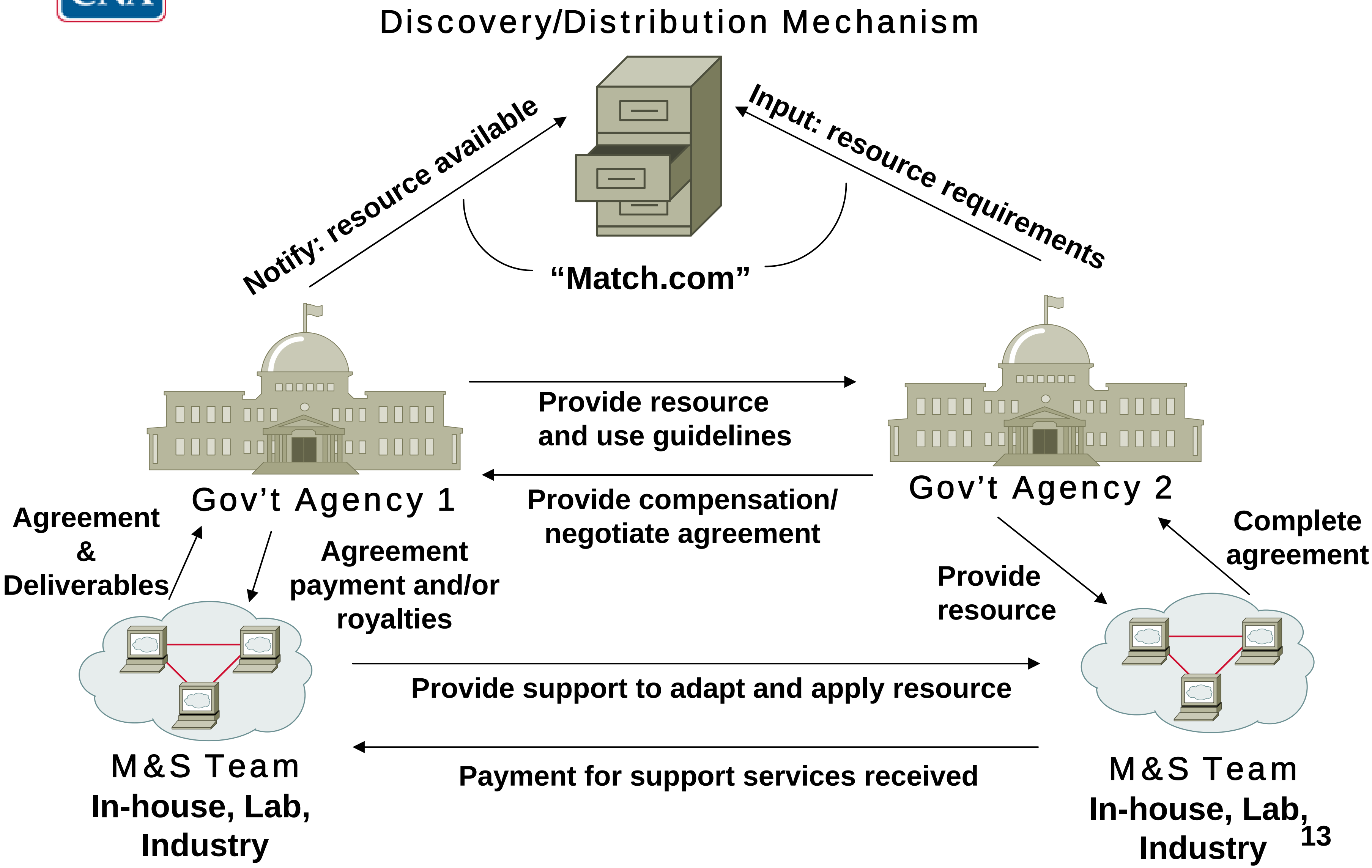
Target Mkt
- PEOs, PMs
- Dir Training
- Hd Analysis
- Service/Component

Customer Relationships
- Discovery tools
- Trust/ MOUs

Distribution channel
- Access control
- IP Intermediaries
- MOUs

Compensation
- Licensing
- Royalties
- Support $$
- Purchase options

M&S Resource Transactions



Study findings *could* include recommendations on:

- Extending Tech Data rights to M&S resources
- Mechanisms to support intra- government transactions
- Measures to encourage open-source software
- Improved discovery and distribution tools

John Warner National Defense Authorization Act for FY2007

CNA

Sec. 802. Additional Requirements Relating to *Tech Data Rights*

- Section 2320 of 10 U.S.C. is amended by adding the following new subsection:
  (e) The Secretary of Defense shall require program managers for major weapon systems and subsystems of major weapon systems to assess the long-term technical data needs of such systems and subsystems and establish corresponding acquisition strategies that provide for technical data rights …
- Motivated by a need to develop alternatives to sustain systems over their lifecycle, including
  - Shifting maintenance to DoD and
  - Re-competing contracts for spare parts
- *Could be extended to include models, simulations, and associated databases developed and/or used in training, acquisition, testing, evaluation, and analysis of weapons systems*
- Motivation is a desire to support upgrades to weapon systems
- Repositories like SHARE, originally established to contain computer software and tech data associated with combat weapon system, could be extended to include M&S software and associated data

Federal Agencies as IP Intermediaries

- NTIS as intermediary for IT and government publications
- NIH Office of Technology Transfer (OTT) as intermediary for IP developed by staff and/or grantees
- NASA Open Source Initiative as a distribution vehicle for software
- NASA IPP as intermediary for IP developed by staff and/or grantees (includes royalty opportunities for innovators)

Examples of Gov-2-Gov Agreements

- **Inter-Governmental Service Agreements (IGSAs)**
  - **Immigration and Customs Enforcement (DHS/ICE) leases space in over 600 state and local jails and prisons in order to house alien detainees; the facilities used include both government-owned and contractor-owned institutions.**
- **Interagency Agreements (IAA)**
  - **Federal Occupational Health (DHHS/FOH) negotiates IAAs with federal agencies to provide on-site health care; services are provided by health care professionals working for FOH as independent contractors.**

Proprietary, non-commercial software poses obstacles to reuse

- Development environment restricted to internal ideas and internal technology
  - No reuse of the work from other organizations
- Often require NDA to look under the hood
  - NDA governs disclosure of models, source code, documentation, databases, drawings, know-how, formulas, processes, concepts, flow charts, designs, ideas, technical plans, …
  - Prohibits copying, altering, modifying, disassembly, reverse engineering, or decompiling the resource
- Can't transfer asset to a third party for reuse

However, the absence of competition and potential for collaboration may lead to monopoly markets in niche areas such as DIME/PMESII

Open Source Software supports reuse

CNA

- OSS breaks through several barriers preventing reuse:
  - Not ready for reuse
  - Components don't play nicely
  - Poor capability assessment
  - Insufficient detail & documentation
  - Difficult to access resources
  - Little info regarding past use
  - Incomplete and not current repositories
  - Resources hard to adapt

  "Not invented here"
- Costs of OSS lower (transition, lifetime, support, upgrades)
- Open standards used in OSS support interoperability, and hence reuse
- Reusables tend to be abstract and harder to engineer. OSS patterns, which are recurring solutions to common software problems, help alleviate this and other reuse impediments.

Improved Discovery tools: Bringing M&S developers and users together

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	Catalog Access to IP Assets	Direct IP Distribution
3^{rd} Party/ External Consolidator	**IP Search Engines** **IP Exchange Platforms**	**Publishers** **Resellers** **iTunes**
Non-Profit/ Government/ Self-Managed	**Library of Congress** **Library Consortia** **Fed. Tech Transfer Sites** **Univ. Tech Transfer Sites**	**Copyright Collectives** **Shareware, Open Source Software Dist.** **Federal Data Sources** **Non-Profit Organizations** **Software Escrow Agents**

External Consolidator, IP Catalog Access

- IP Search Engines
  - Cambia Patent Lens*
  - Delphion Research
  - Google Patents
  - PatentCafe
  - PIPRA*
  - Thompson Dialog
  - Thomson MicroPatent
  - Thomson Pharma
  - WIPO Digital Patent Library*

(*nonprofit organization)

- iTunes
- IP Exchange Platforms
  - BirchBob
  - Idea Trade Network
  - MVS Solutions
  - PharmaTransfer
  - TechEx
  - Yet2

External Consolidator, IP Distributors

- Publishers
  - IEEE Xplore
  - Elsevier SciDirect
  - Nat'l Acad. Press
  - Lexis, Westlaw
  - Newspaper web sites
- iTunes
- Resellers of Copyrighted Material
  - JSTOR
  - EBSCOHost
  - Ingenta/Uncover

Self-Managed, IP Catalog Access

- Library of Congress On-Line Catalog
- Library Consortia
  - Membership (ex: On-Line Computer Library Center, oclc.org)
  - Open access (ex: Washington Research Library Consortium, wrlc.org)
- Fed Tech Xfer
  - NASA
  - NIH
  - NIST
  - DoD, including IACs
  - Other Fed CRADA
- Univ. Tech Xfer
  - See Association of University Technology Managers (autm.net) for background

Self-Managed IP Distributors

Copyright collectives:
- ASCAP, BMI (in US)
- ALCS (in UK)
- JASARAC (in Japan)

Shareware Distributors
- Tucows, tucows.com
- PC Magazine/ Digital River, www.regnow.com

Open Source Software Dist.
- ossid.org (background)
- opensource.org
- redhat.org
- NASA Open Source Initiative, opensource.arc.nasa.gov

Federal Data Sources
- gpo.gov, thomas.loc.gov
- Bureau of the Census
- Bureau of Labor Statistics
- National Weather Service
- Department of Energy

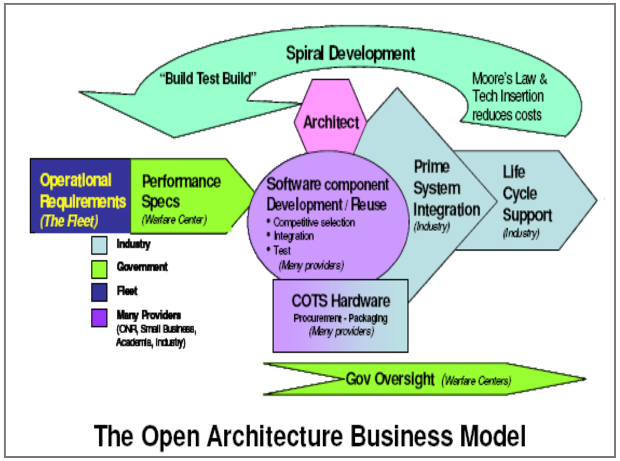
Non-profits
- FFRDCs (sei.cmu.edu, CNA, RAND, IDA)
- “Think Tanks” (AEI, Brookings, Cato, Urban Institute, etc.)
- Constituency Organizations (Ex: eff.org, aarp.org)

Escrow Agents
- Example: innovasafe.com

Summary: A business model takes reuse

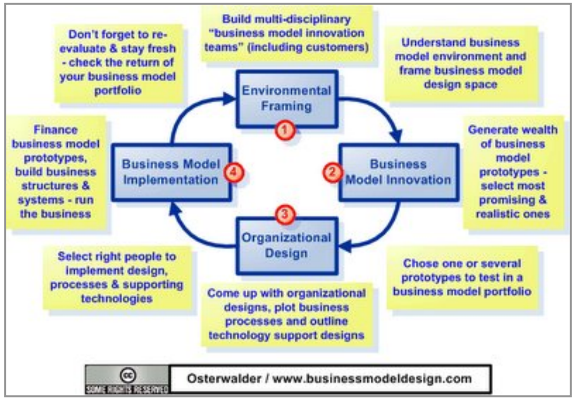
From Field of Dreams, To Government Contracting, To Business Viability

Build it and they will come…



The Open Architecture Business Model

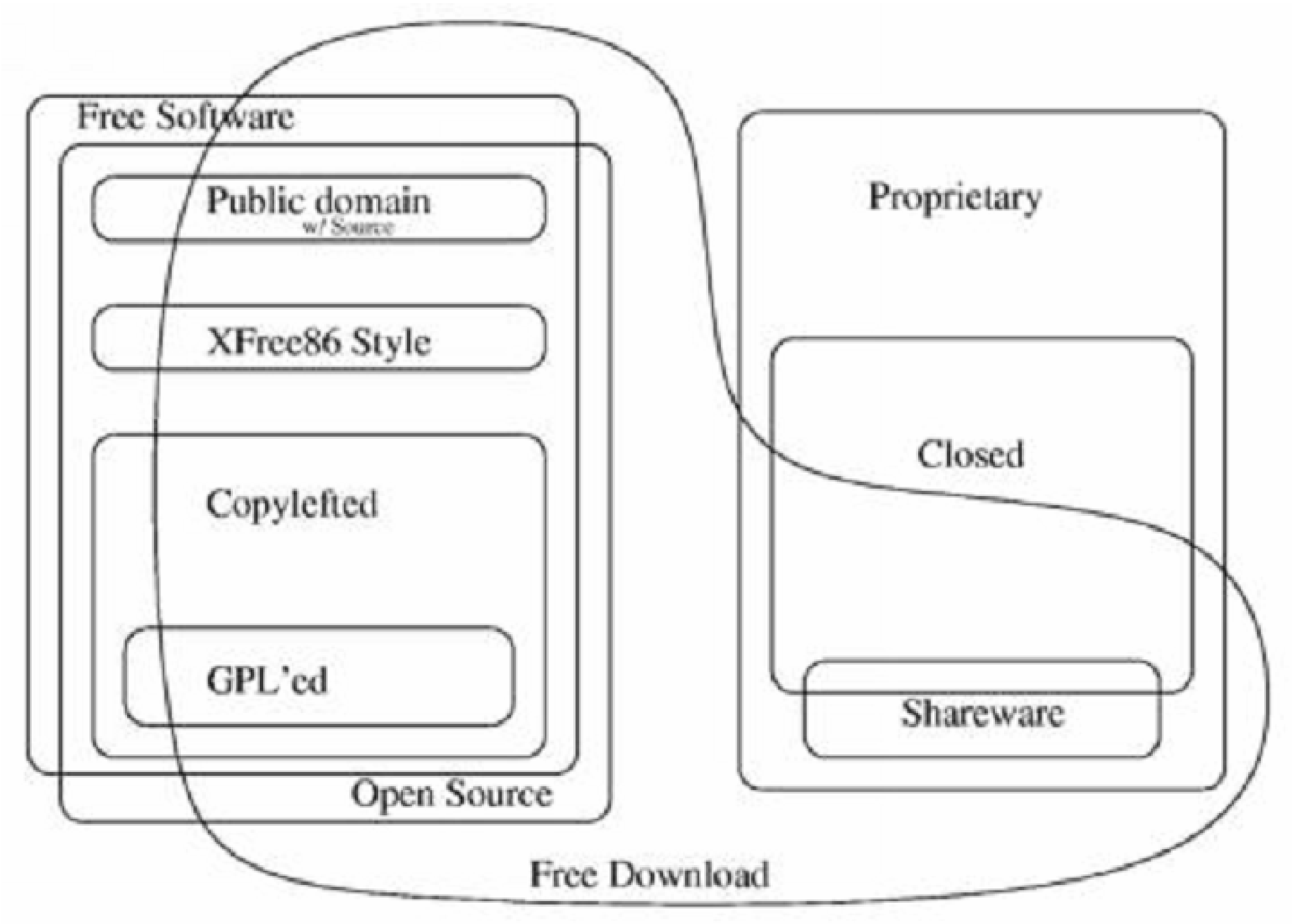
Make it work w/n DoD contracting…



Make it profitable for participants…

Backup

Software Copyright Overview



Exactly What is Open Source Software?

- THE Open Source (partial) Definition:
  - Free redistribution (no royalty or fee)
  - Source code must be provided or made otherwise freely available, upon redistribution
  - Source code can be modified. Derived works can be redistributed under terms of original license
  - Same rights provided to all recipients
  - No restriction on other software bundled with the OSS
- Source code distribution is only required by GNU’s General Public License (GPL) and Lesser GPL, and then only upon distribution of work derived from the original source.
  - So, OSS ok for sensitive/classified software!

Open Source Software in the Private Sector

- OSS is found throughout the private sector:
  - Apache (web server)   , Linux, Java
  - MySQL (database)
  - Other middleware and internet infrastructure
  - Supercomputing clusters in academia (Virginia Tech, Penn State, Georgia Tech, etc.) running OSS
  - Parallel high-performance computing tools: OpenMP, Open MPI, MPICH
- Delta3D, Genesis3D, & Irrlicht engines, for 3D simulations and games
- IBM invested over $1B in Linux development and promotion
- Sun developed Star Office to compete with MS Office and then opened the source. The result is Open Office, which is MS Office compatible and uses the Open Document format also.
- Several other companies have sponsored or contributed to OSS: Boeing, Northrop Grumman, Novell

Open Source in DoD

- US Army is single largest install base of Red Hat Linux
- Open Source Software Image Map (OSSIM) project
  - High performance software system for remote sensing, image processing, geographical information systems and photogrammetry.
  - OSSIM (pronounced "Awesome") currently deployed for commercial and government use… e.g. provides imagery to NASA and Google Earth, embedded in several classified and sensitive solutions in intelligence community.
- OneSAF: A simulation, training and instrumentation environment
  - Used by US Army and USMC (embedded simulation engine for US Army Future Combat Systems)
  - Virtually unlimited in creating virtual military environments.
- OpenEaagles: USAF simulation environment
- SubrScene: real-time simulation visualization toolkit.
  - Used by USAF for emersion in virtual environments for 3D fly-through

Other Federal Government Open Source Software initiatives

- NASA - Has released over 20 open source apps
  - CosmosCode initiative: enlists volunteers to develop code for space missions
  - Supercomputer (one of world's most powerful) uses SGI Linux
- Navy Open Architecture - actively encourages open source and standards in acquisitions
- FAA saved $15M and 12 months switching to Red Hat Linux (from Unix) on air traffic control computers
- USAF, National Oceanographic and Atmospheric Admin. use SGI Linux.
- Army Future Combat System – uses Linux and open source simulation software
- Defense Medical Logistics Standard Support
  - Apache, OpenSSL, ModSSL, Stunnel
- Navy - Total Ship Computing Environment Initiative (TSCEI) runs on Red Hat Linux
  - Will support carriers, amphibious ships, destroyers, ...

Center for Advanced Aviation System Development (CAASD)

FINAL

The Use of Enterprise Architecture to Support the Development of the Next Generation Air Transportation System (NextGen)

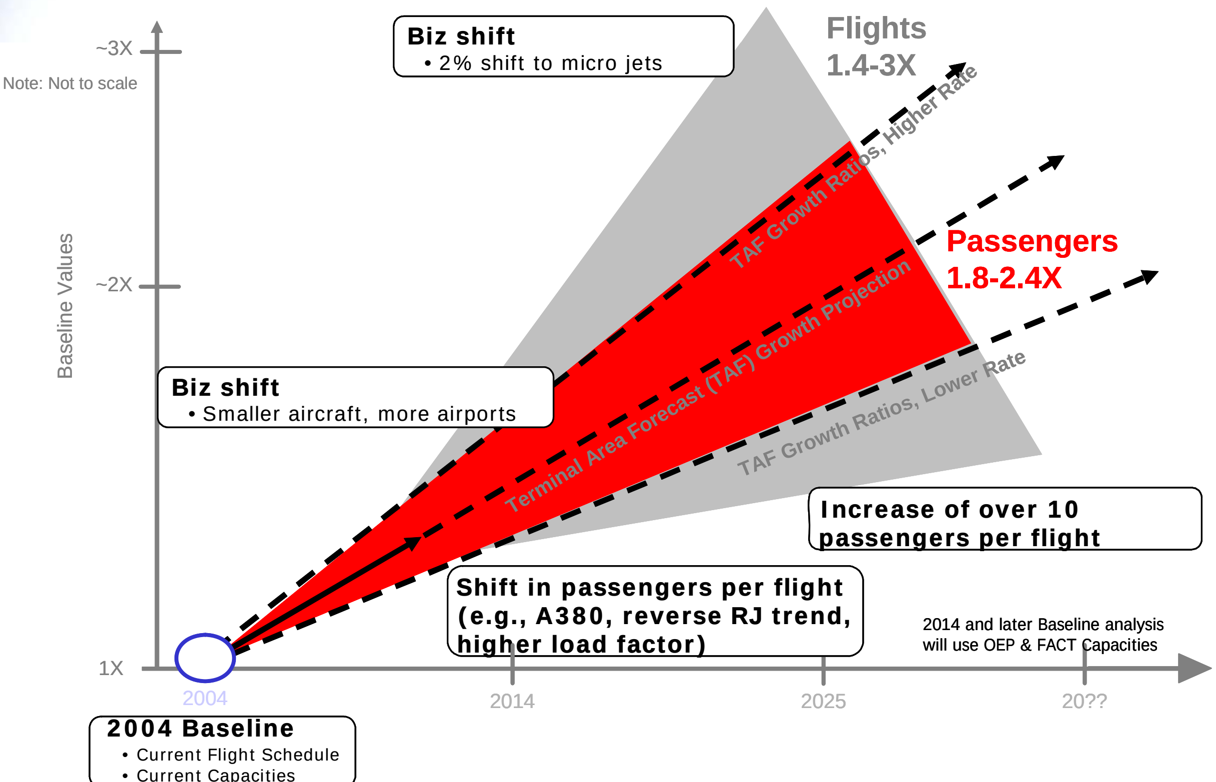
David Snyder (MITRE)
Gerald Friedman (MITRE)
Jay Merkle (FAA)

25 October 2007

Outline

- Introduction
- Background
- Approach
- Lessons Learned
- Summary

Why NextGen?



- Growth in volume and complexity of operations
- Scalable to encompass a range of possible futures
- Broader diversity of:
  - Aircraft performance characteristics
  - Aircraft capabilities
  - Operator business models
- Space Operations
- Unmanned Aerial Systems

Transformation is Needed to Accommodate Projected Traffic Levels and Characteristics

MITRE

Vision 100 Legislation – JPDO Responsibilities

- **Create and carry out an integrated plan to achieve NextGen**
- **Coordinate goals and priorities for research and development**
- **Coordinate research activities within the Federal Government and across United States aviation and aeronautical firms**
- **Facilitate the transfer of technology from research programs to Federal agencies with operational responsibilities and to the private sector**
- **Create a transition plan for the implementation of NextGen**

➢ ***Operate in conjunction with relevant programs in specified government agencies***

➢ ***Consult with the public and ensure the participation of experts from the private sector***

MITRE

Scope of NextGen

Next Generation Air Transportation System (NextGen)

- Envisioned 2025 system and transition from today
- Satisfy capacity, efficiency, safety, defense, and security needs
  - Responsive to environmental concerns
  - Responsive to global harmonization requirements
- Planned jointly by public and private sector stakeholders through JPDO
  - Civil aviation, National Defense, Homeland Security, and Transiting Spaceflight

MITRE

What is NextGen?

Transformation goals:

- Leadership in global aviation
- Scalable up to 3x increase in capacity
- Ensure our national defense (readiness and homeland security)
- Enhance the environment (noise, air quality)
- Improve safety
- Globally harmonized

Capabilities:

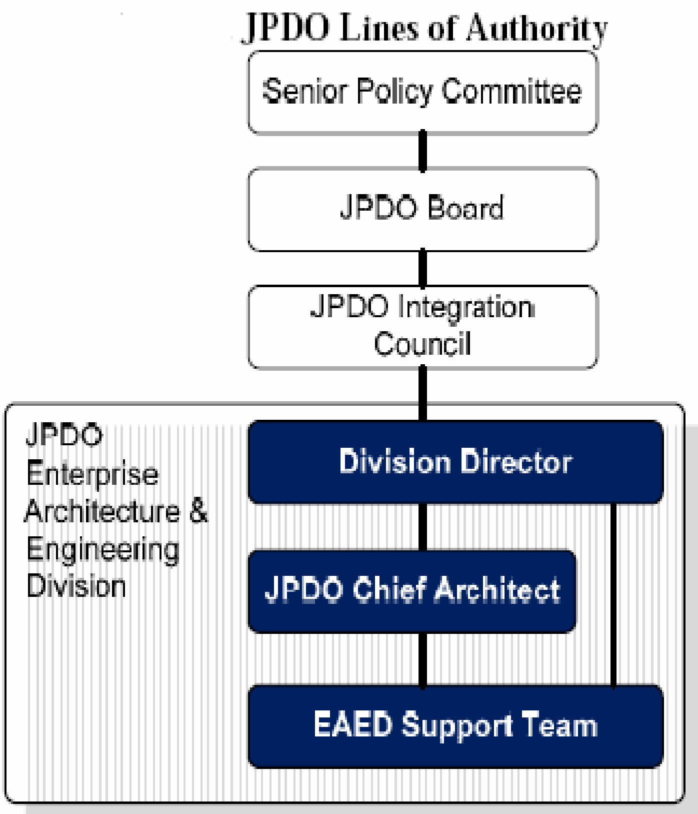
- Network-Enabled Information Access
- Performance Based Operations & Services
- Weather Assimilated into Decision Making
- Layered, Adaptive Security
- Position, Navigation, and Timing Services
- Aircraft Trajectory Based Operations
- Equivalent Visual Operations
- Super Density Arrival/Departure Operations

MITRE

Organization Developing the NextGen EA

Organization Developing the Architecture

The NextGen Enterprise Architecture is developed and maintained by the Enterprise Architecture and Engineering Division (EAED) of the Joint Planning Development Office (JPDO), an Executive Office created to support and coordinate the efforts of Government and Private organizations in the development of the Next Generation Air Transportation System as envisioned by the President's "Vision 100" operational concept.



Source: "Joint Planning and Development Office – Program Management Plan V1.0 for the Enterprise Architecture and Engineering Division", produced by the JPDO EAED, dated 22 June 2007.

MITRE

Roles and Responsibilities

- **Government Leadership**
  - **EAED – Division Director – Mr. Ed Waggoner**
    - **Directs all EAED activities and in charge of all staff that support EAED**
    - **Represents the EAED on the JPDO Integration Council**
  - **EAED – Chief Architect – Mr. Jay Merkle**
    - **Responsible for leading the development, coordination, collaboration, and validation of the NextGen ConOps, EA and IWP.**

- **Booz Allen & Hamilton: JPDO - EAED primary support contractor, primary responsibilities:**
  - **Provide support and guide the development of the EAED concepts and development practices**
  - **Identify architecture-related issues and actions that need to be addressed**
  - **Develop and review architectural-related products**
  - **Manage and implement approved architectural changes**

- **MITRE: JPDO EAED FFRDC, primary responsibilities:**
  - **Provide guidance and recommendations to inform the development of engineering products.**
  - **Perform independent technical review and validation of major JPDO engineering products.**
  - **Help ensure products are appropriate in terms of content and structure and will identify integration needs, dependencies and areas requiring alignment among the products**

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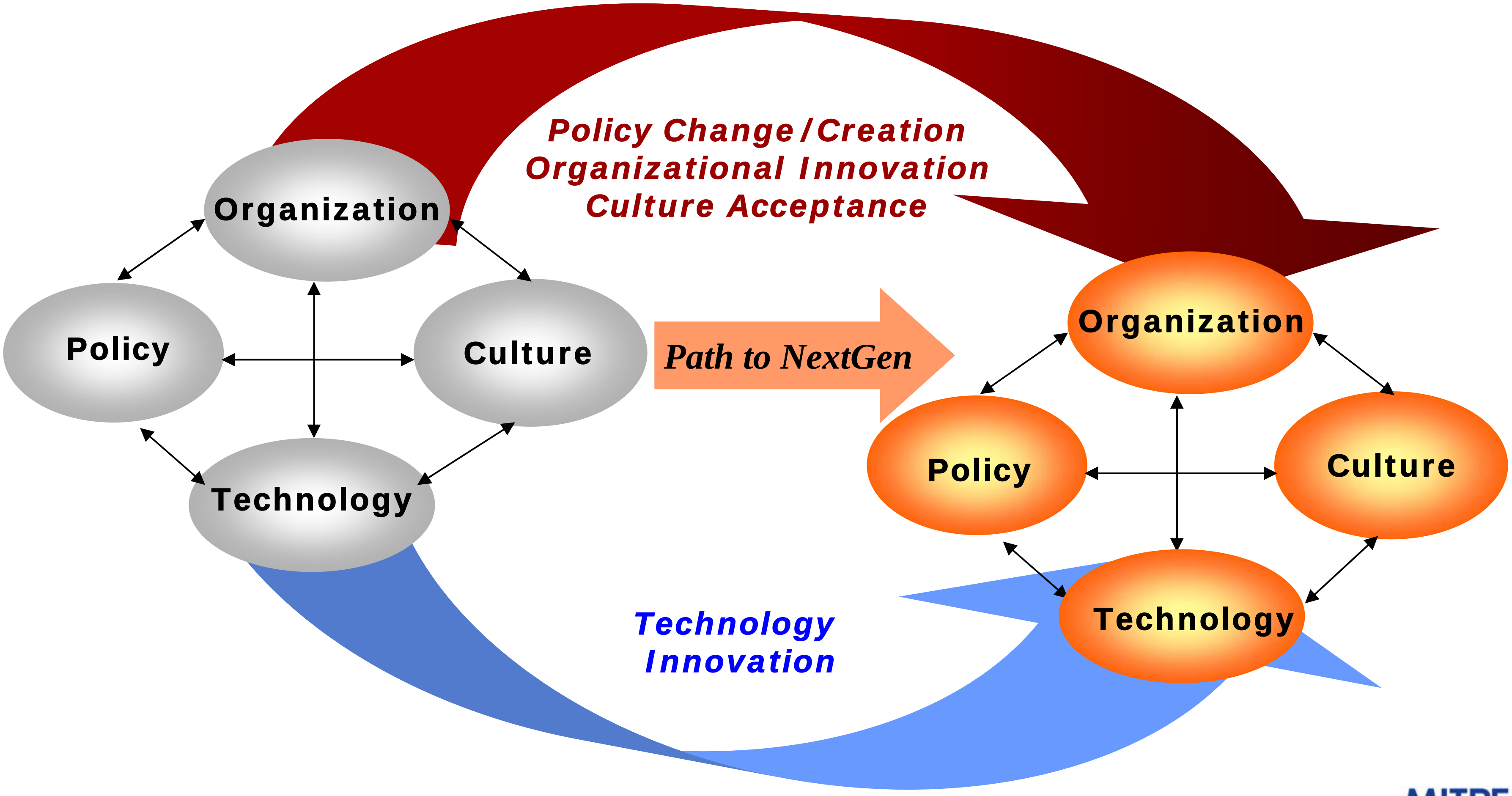
Approach

System-Wide Transformation

NextGen Requires Innovation Across All Lines of Development



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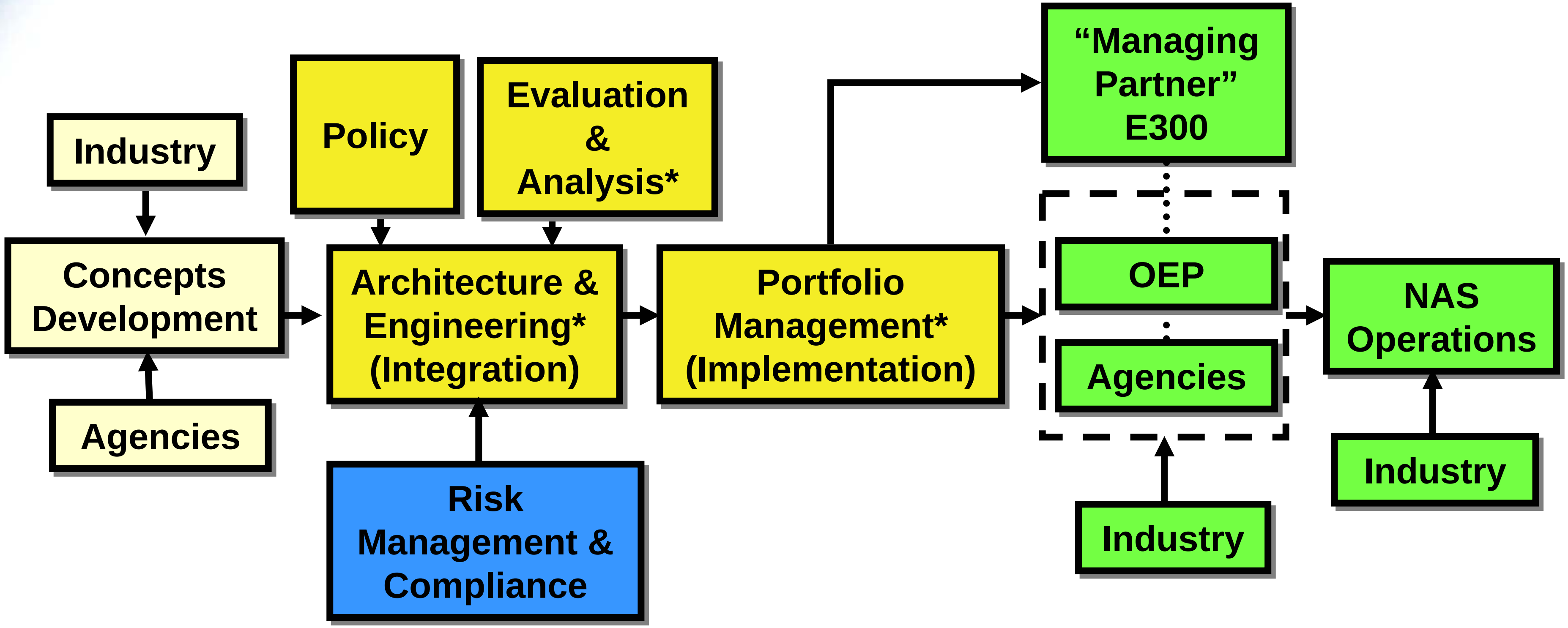
Planned Implementation Process



Source: Briefing titled "The Next Generation Air Transportation System – EAED Products Status" by Dr. Edgar Waggoner, dated 16 May 2007.

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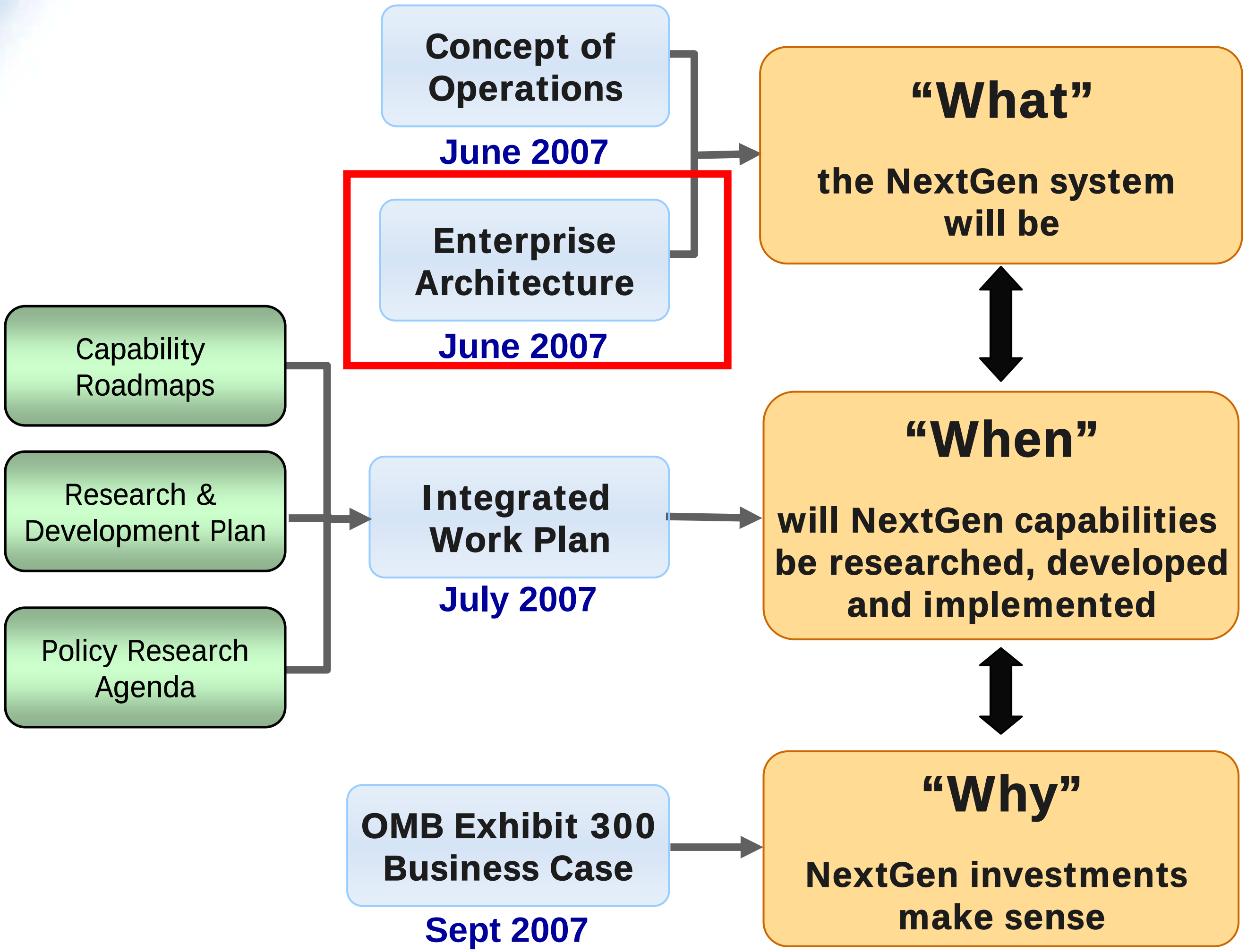
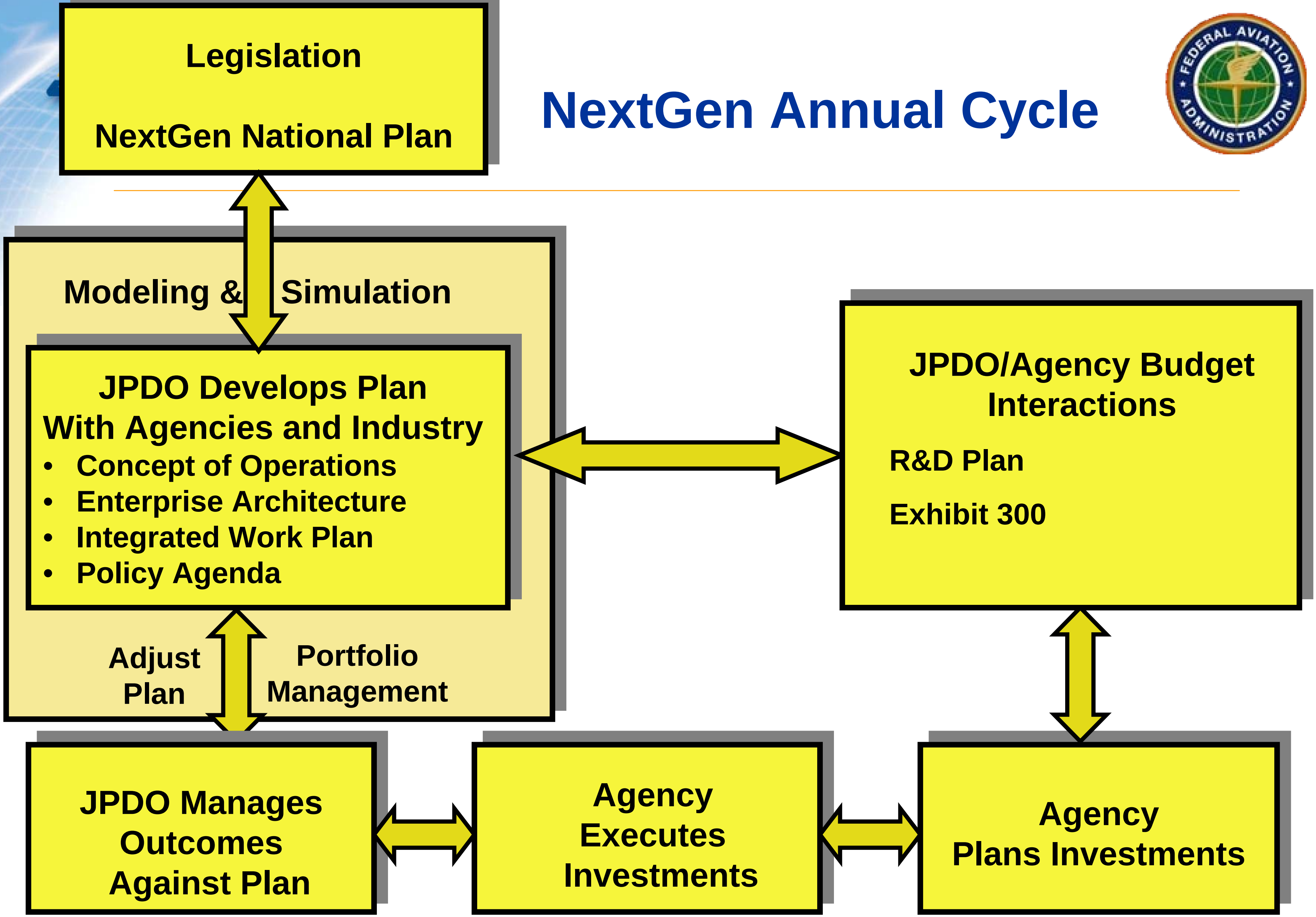
NextGen Planning Products



Source: Briefing titled “NextGen 101 – Next Generation Air Transportation and the Joint Planning and Development Office Orientation”, by MITRE, dated June 2007.

NextGen Annual Cycle

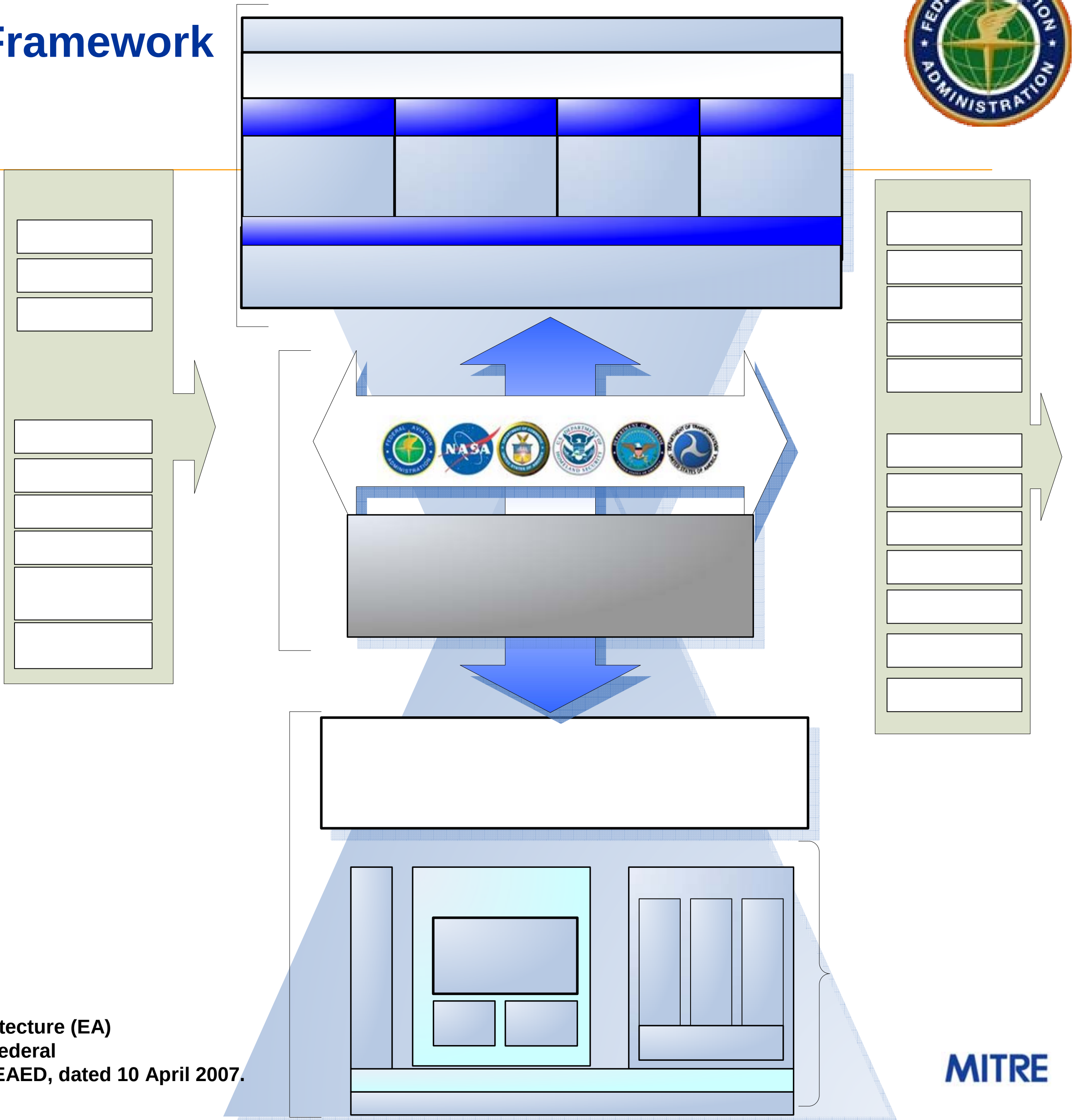


Source: Briefing titled "The Next Generation Air Transportation System – EAED Products Status" by Dr. Edgar Waggoner, dated 16 May 2007.

Key NextGen Products from Enterprise Architecture and Engineering

NextGen EA Framework

- Is a combination of the Federal Enterprise Architecture (**FEA**) and DoD Architecture Frameworks (**DoDAF**), products and processes
- The DoDAF OV5 along with the FEA business reference model (BRM) act as the integration mechanism of the two frameworks
- Establishes a common lexicon and creates a starting point for partner agencies to align and “drill-down” their respective architectures



Source: Briefing titled “NextGen Enterprise Architecture (EA) Focus: Federal Enterprise Architecture (FEA) & Federal Transition Framework (FTF) Initiatives” by JPDO EAED, dated 10 April 2007.

CENTER FOR ADVANCED AVIATION SYSTEM DEVELOPMENT (CAASD)

Use of OMB Federal Enterprise Architecture Reference Models (FEA RMs) in Support of NextGen EA

Proposing a new FEA BRM Line of Business (LOB) called "Air Transportation"

Services for Citizens ← Existing Business Area

- **Transportation** ← Existing Line of Business
  - **Space Operations**
  - **Ground Transportation**
  - **Water Transportation**
  - **Air Transportation**

← Existing Sub-functions

The proposed Air Transportation LOB would provide 14 new Sub-Functions based on the OV5 Activity Model

Air Transportation

- Weather Operations
- Positioning, Navigation & Timing Operations
- Surveillance Operations
- Flight Planning & Flight Data Management
- Aeronautical Information Management
- Safety Management Operations
- Communication Service Management
- Airport Support
- Airport Operations
- Air Navigation Support
- Airspace Security Operations
- Air Navigation Operations
- Flight Support
- Flight Operations

Proposed Sub-functions

Source: Briefing titled "NextGen Enterprise Architecture (EA) Focus: Federal Enterprise Architecture (FEA) & Federal Transition Framework (FTF) Initiatives" by JPDO EAED, dated 10 April 2007.

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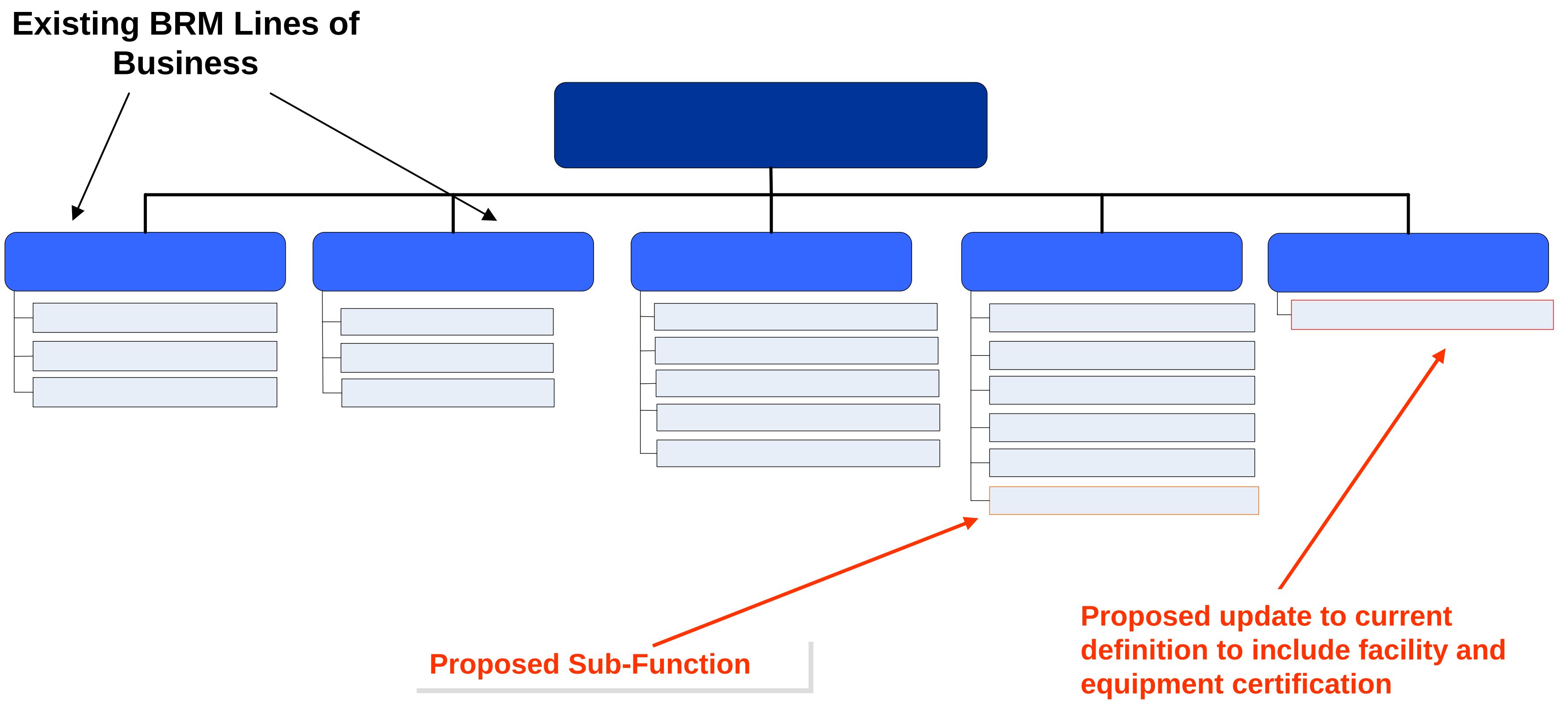
Additional BRM Revision Proposals

Proposing an additional Sub-Function under existing IT Management Line of Business



Source: Briefing titled "NextGen Enterprise Architecture (EA) Focus: Federal Enterprise Architecture (FEA) & Federal Transition Framework (FTF) Initiatives" by JPDO EAED, dated 10 April 2007.

Proposed Extensions to Existing SRM

Proposing a **new** “Operational Services” Domain made up of 9 Service Types and 26 Service Components

Proposed Service Types

Proposed Domain

Proposed Service Components

- **Operational Services**
  - **Surveillance Services**
    - Cooperative
    - Non-Cooperative
  - **Navigation Services**
    - Positioning
    - Navigation
    - Timing
  - **Certification Services**
    - Facility/Equipment Certification
    - Info. System/Application Certification
    - Personnel Certification/Licensure
    - Operation Certification/Licensure
  - **Weather Information Services**
    - Weather Forecasting
  - **Voice/Data Communication Management Services**
    - Ground Network
    - Air to Ground Network
    - Network Infrastructure
  - **Performance Management Services**
    - Monitoring
  - **Airspace Management Services**
    - Airspace Design
    - Airspace Management
  - **Flight Management Services**
    - Flight Planning
    - Flight Tracking
    - Aeronautical Information Mgmt
    - Trajectory Management
    - Separation Analysis
    - Flow Contingency Mgmt
  - **Security Services**
    - Secure People
    - Secure Baggage/Cargo
    - Secure Facilities/Equipment
    - Secure Airspace

Source: Briefing titled “NextGen Enterprise Architecture (EA) Focus: Federal Enterprise Architecture (FEA) & Federal Transition Framework (FTF) Initiatives” by JPDO EAED, dated 10 April 2007.

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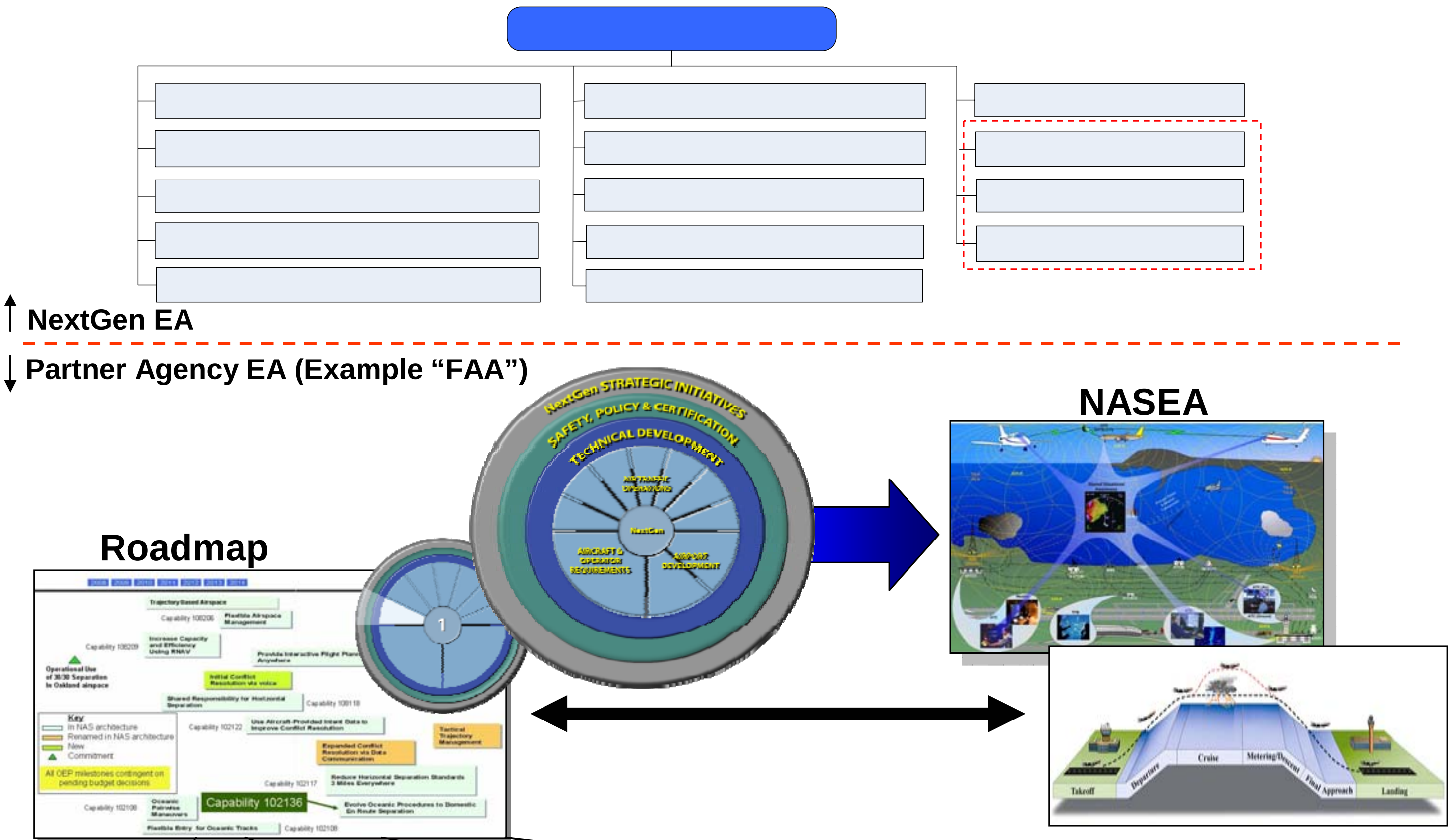
Using the Proposed BRM Reference Model Extension



Programs				
En Route Automation Modernization (ERAM)	*NextGen Collision Avoidance System*	*NextGen Traffic Flow Management*	*SWIM*	*Aeronautical Data Link*

Source: Briefing titled "NextGen Enterprise Architecture (EA) Focus: Federal Enterprise Architecture (FEA) & Federal Transition Framework (FTF) Initiatives" by JPDO EAED, dated 10 April 2007.

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Weather Operations

Use of FEA Reference Model in Support of NextGen EA (cont'd)

The JPDO, working in conjunction with the OMB FEA office, will develop an instantiation of the five OMB FEA reference models which will:

- Form the core of the enterprise level of the NextGen EA. The JPDO will apply the reference models to support comparisons of architectures from participating agencies and organizations.
- Help identify gaps and overlaps in capabilities, operations, information and systems.
- Help identify key areas of commonality across the organizations that will require improved integration and coordination.
- Frame and organize the NextGen target (to-be) architecture so that participating agencies can align with its goals and content.
- Ensure traceability from the NextGen target architecture to the FEA reference models to facilitate architecture and investment review.

Center for Advanced Aviation System Development (CAASD)

Federal Aviation Administration

Use of the DoD Architectural Framework (DoDAF) to Support the Development of the NextGen EA

CAASD

MITRE

Summary of NextGen EA DoDAF Products

DoDAF Product	Purpose
Overview and Summary (AV-1)	The AV-1 gives the reader a condensed overview of the content of the architecture, including information about the reason for developing the architecture, the architectural products that will be developed to support that purpose, the kinds of analyses to be conducted on the products, who will conduct them, and how the results will be used. The AV-1 provides a summary of the vision, mission, architecture products, assumptions and constraints, and tools used in the process of developing the architecture.
Integrated Dictionary (AV-2)	The AV-2 is the NextGen EA's common consistent language, reducing confusion and increasing understanding for partner agencies and stakeholders. It enables the JPDO to collaborate and socialize the NextGen EA with a consistent lexicon formatted in such a way that stakeholders can compare the elements of the NextGen EA to their respective integrated dictionaries and architectures and propose changes if necessary to ensure the community is using terms consistently and as intended.
Community Model (OV-1)	The Community Model (OV-1) is used to provide a high level pictorial description of the major organizational and operational elements of the Next Generation Air Transportation System and how those elements interact with each other and with their environment.
Operational Node Connectivity Description (OV-2)	The operational nodes shown in the NextGen EA represent idealized places or organizations where activities are performed that require and/or produce information. The OV-2 is provided not only to represent the various organizations and places where activities are performed but also to provide a framework for organizing the information exchanges that will be described in detail in the Operational Information Exchange Matrix, OV-3.
Operational Information Exchange Matrix (OV-3)	The OV-3 is the most comprehensive description of operational information flow. It further decomposes the information flows (needlines) identified in the OV-2 into one or more (usually many) specific Information Exchanges and collects the detailed information about each exchange.

Source: "Enterprise Architecture V2.0", produced by the JPDO EAED, dated 22 June 2007.

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Summary of NextGen EA DoDAF Products (cont'd)

DoDAF Product	Purpose
Activity Model – Hierarchy Node Tree (OV-5)	The OV-5 Operational Activity Hierarchy provides a comprehensive structured list of all the operational activities of interest to the architectural description. That is, it shows all the activities that need to be considered to achieve the desired outcomes of the architectural analysis and how high level activities are composed of lower level activities. The NextGen EA OV-5 Hierarchy also shows how the operational activities align within the eight Enterprise Segments and the relevant Activity Services in the Community Model.
Activity Model—IDEF0 (Activity Flow Diagrams) (OV-5)	The OV-5 Activity Flow diagram provides information useful in streamlining, combing, or eliminating activities, and it is helpful for eliminating redundancy. Of the greatest importance is that the OV-5 Activity Flow diagram provides the foundation for the OV-3 and OV-6c diagrams that are necessary to understand issues of information distribution and timing – critical issues for developing a NextGen EA that will provide the performance improvements required by the NextGen Vision.
Operational Event/Trace Description (OV-6c)	The Operational Event/Trace Description provide a time ordered sequence of information exchanges among the operational activities. Because the JPDO will use the architecture as a basis for advising stakeholders on the value and criticality of improving their systems and processes to achieve the goals of NextGen, an understanding of the sequencing of operational activities could provide key insights in support of that guidance.
Operational Activity to Stakeholder Investment Traceability Matrix (SV-5Hybrid)	To assist Stakeholder Communities of Interest in aligning the NextGen EA activities to their respective architectures and Capital Investment Plans, JPDO has deviated from the standard SV-5, Operational Activity to System Function format prescribed by DoDAF. The NextGen SV-5Hybrid relates Operational Activities to the Stakeholder Investments. By relating NextGen EA Operational Activities to Stakeholder Investments, the SV-5Hybrid describes the key relationships between Stakeholder Capital Investment and NextGen Capabilities.

Source: "Enterprise Architecture V2.0", produced by the JPDO EAED, dated 22 June 2007.

NextGen Community Model 1st Tier

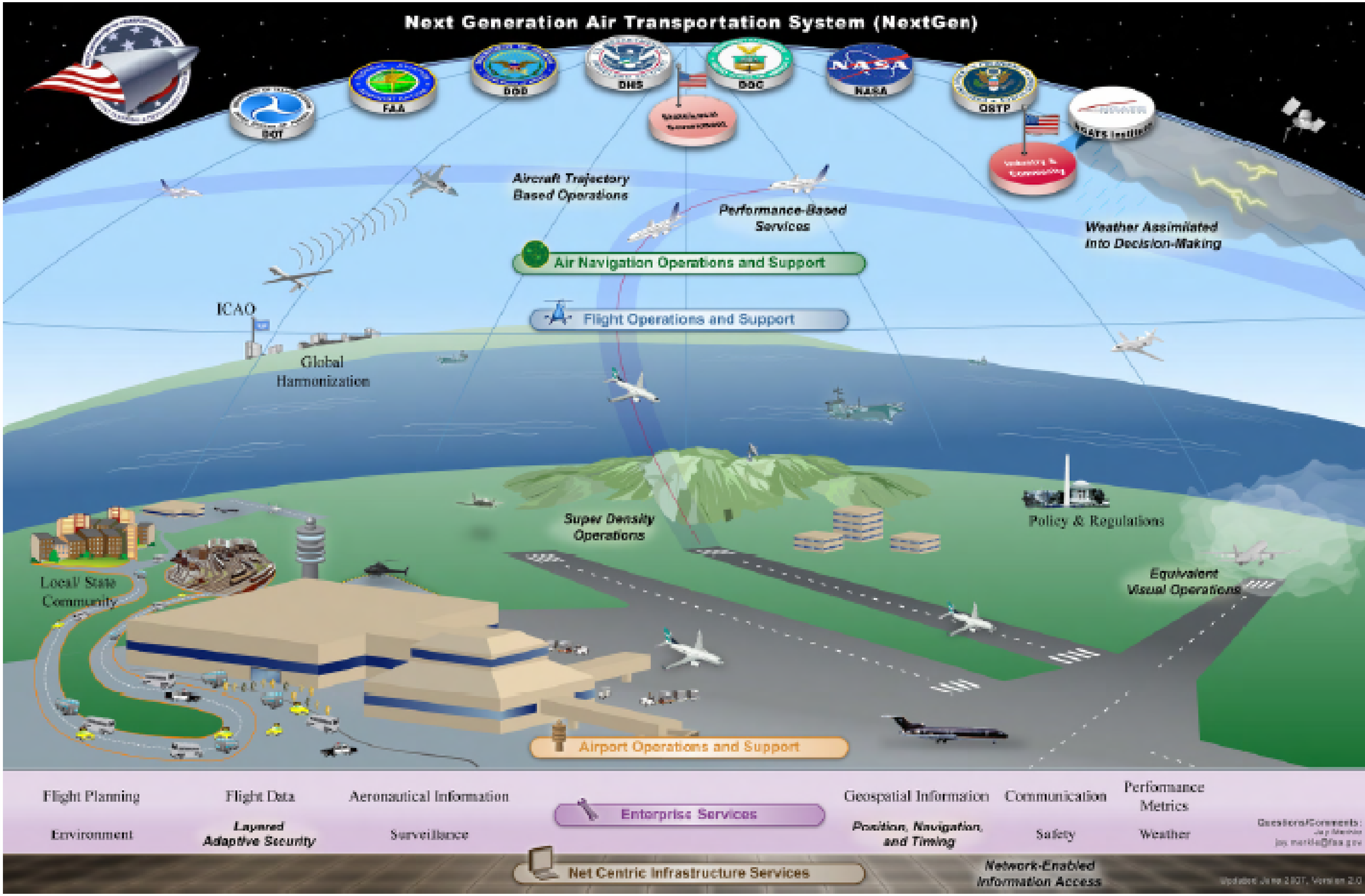
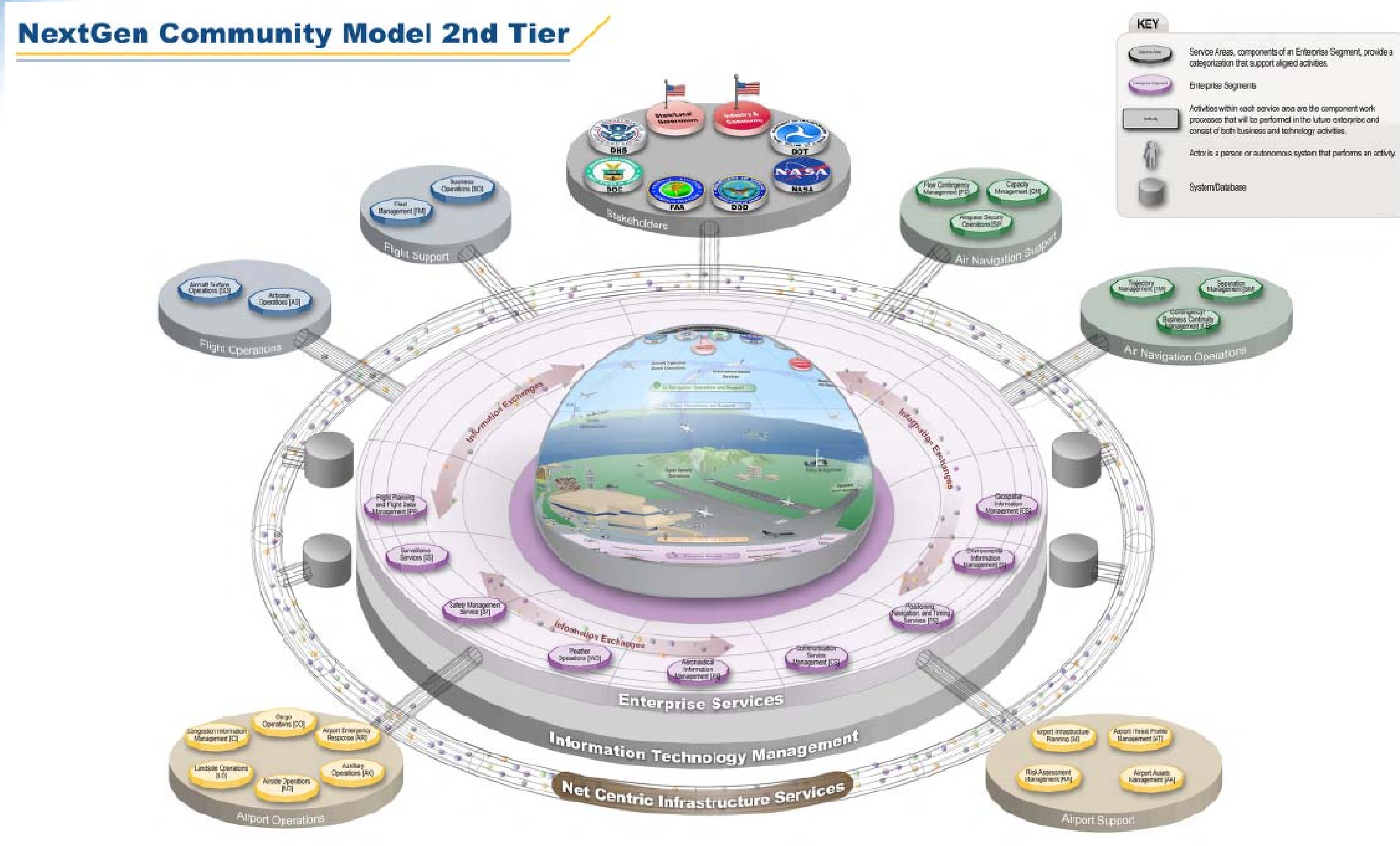


Figure 16: 1st Tier -- NextGen Community Model

Source: "Enterprise Architecture V2.0", produced by the JPDO EAED, dated 22 June 2007.

NextGen Community Model 2nd Tier



Source: "Enterprise Architecture V2.0", produced by the JPDO EAED, dated 22 June 2007.

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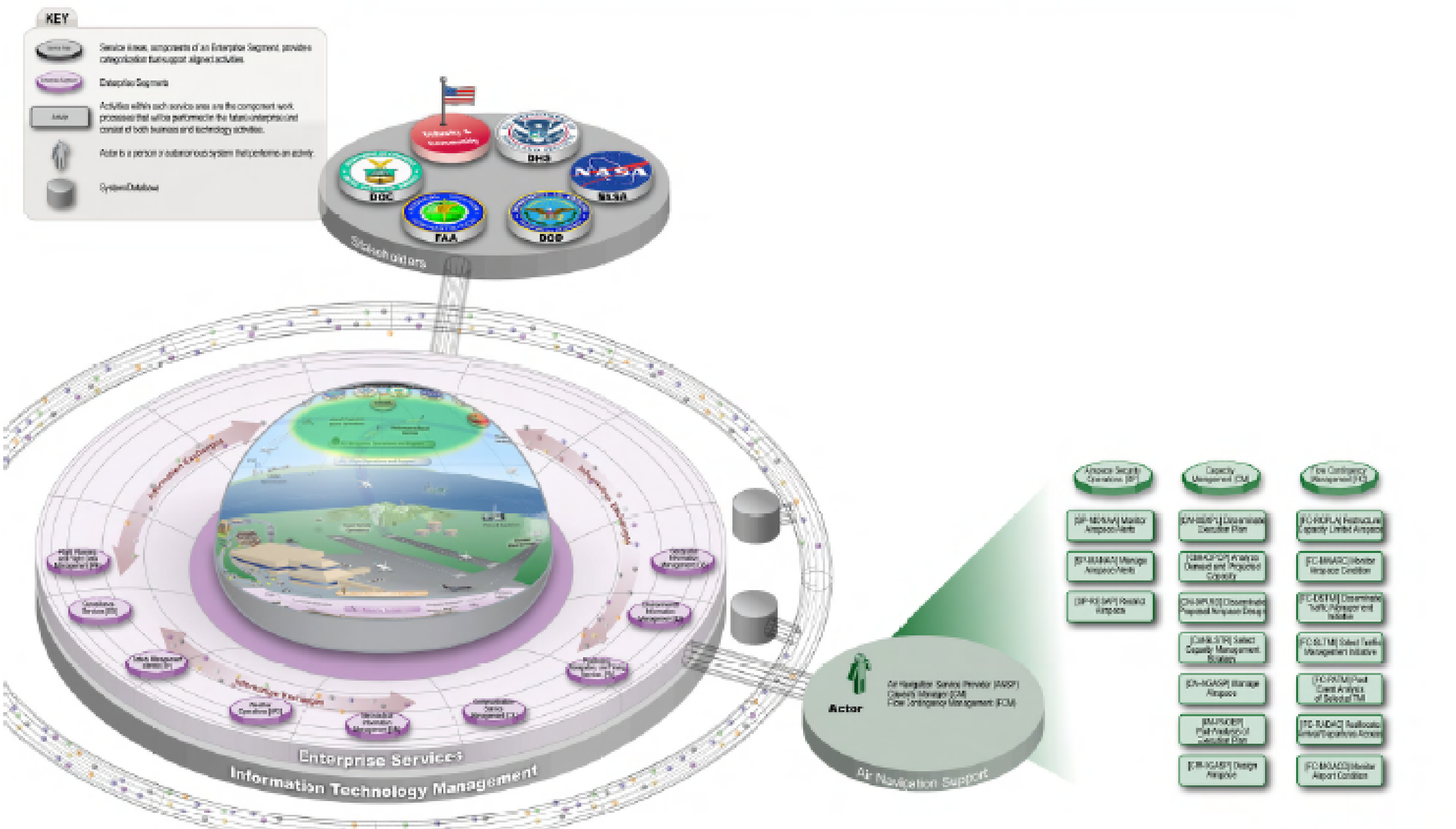
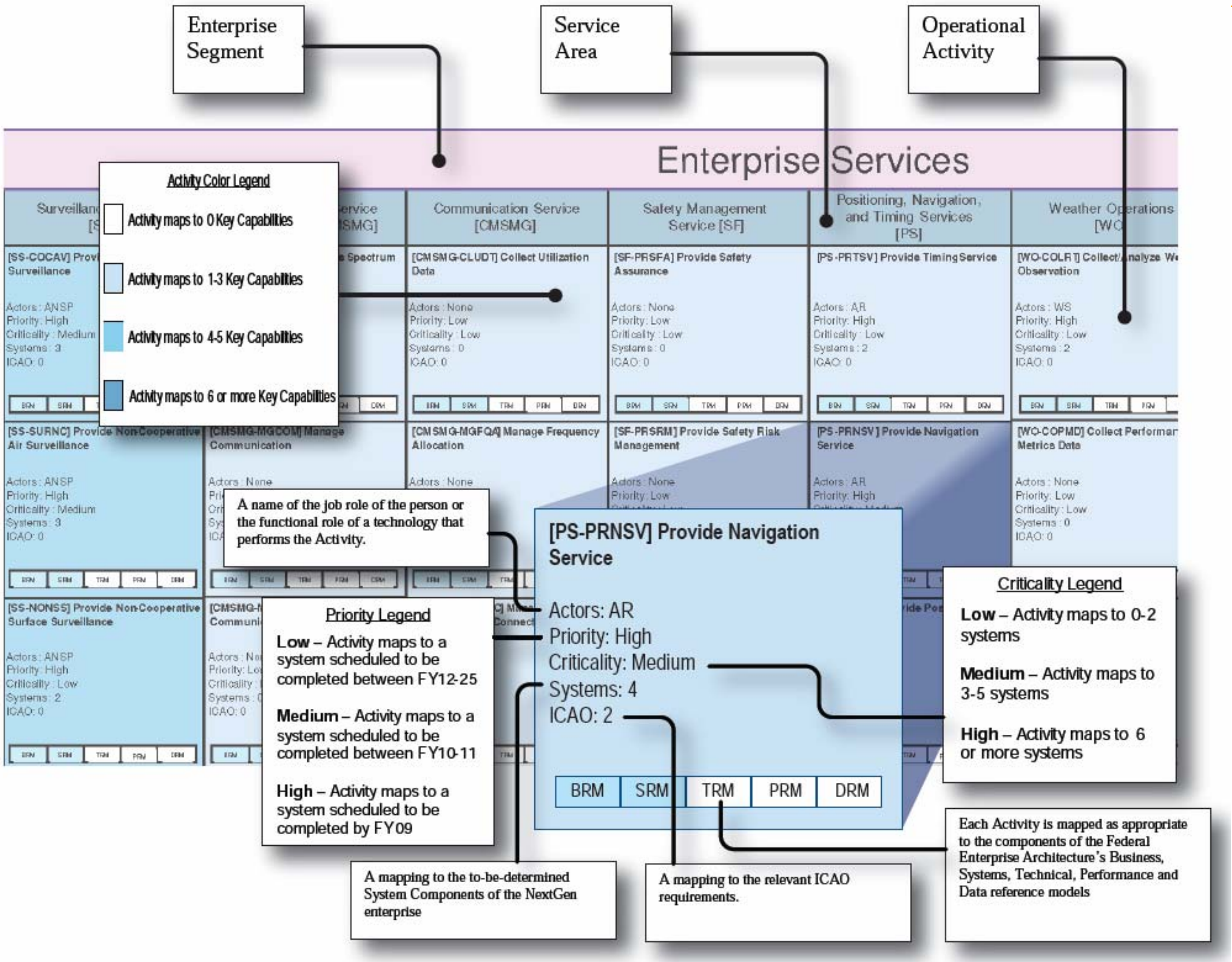
Representative Subset of DoDAF Products

NextGen Community Model 3rd Tier – Air Navigation Support



Source: "Enterprise Architecture V2.0", produced by the JPDO EAED, dated 22 June 2007.

Enterprise Segment Activity Inventory (ESAI)



Source: "Enterprise Architecture V2.0", produced by the JPDO EAED, dated 22 June 2007.

Enterprise Segment Activity Inventory – Air Navigation Support (ESAI)

Air Navigation Support

Flow Contingency Management [FC]	Capacity Management [CM]	Airspace Security Operations [SP]
[FC-MOACD] Monitor Airport Condition Actors: FM Priority: Low Criticality: Low Systems: 0 ICAO: 1 BRM SRM TRM PRM DRM	[CM-DGASP] Design Airspace Actors: CM Priority: High Criticality: Medium Systems: 4 ICAO: 2 BRM SRM TRM PRM DRM	[SP-RESAP] Restrict Airspace Actors: AN,SC Priority: Low Criticality: Low Systems: 0 ICAO: 1 BRM SRM TRM PRM DRM
[FC-RADAC] Reallocate Arrival/Departures Access Actors: FM Priority: Low Criticality: Low Systems: 0 ICAO: 3 BRM SRM TRM PRM DRM	[CM-MGASP] Manage Airspace Actors: CM Priority: High Criticality: Medium Systems: 4 ICAO: 1 BRM SRM TRM PRM DRM	[SP-MANAA] Manage Airspace Alerts Actors: AN,SC Priority: Low Criticality: Low Systems: 0 ICAO: 0 BRM SRM TRM PRM DRM
[FC-PATMI] Post-event analysis of selected TMI Actors: FM Priority: Low Criticality: Low Systems: 0 ICAO: 2 BRM SRM TRM PRM DRM	[CM-PAOEP] Post-analysis of Execution Plan Actors: CM Priority: Low Criticality: Low Systems: 0 ICAO: 1 BRM SRM TRM PRM DRM	[SP-MONAA] Monitor Airspace Alerts Actors: AN,SC Priority: Low Criticality: Low Systems: 0 ICAO: 0 BRM SRM TRM PRM DRM
[FC-SLTMI] Select Traffic Management Initiative Actors: FM Priority: Low Criticality: Low Systems: 0 ICAO: 1 BRM SRM TRM PRM DRM	[CM-SLSTR] Select Capacity Management Strategy Actors: CM Priority: Low Criticality: Low Systems: 0 ICAO: 0 BRM SRM TRM PRM DRM	
[FC-DSTMI] Disseminate Traffic Management Initiative Actors: FM Priority: Low Criticality: Low Systems: 0 ICAO: 2 BRM SRM TRM PRM DRM	[CM-DPARD] Disseminate Proposed Airspace Design Actors: CM Priority: Low Criticality: Low Systems: 0 ICAO: 2 BRM SRM TRM PRM DRM	
[FC-MNARC] Monitor Airspace Condition Actors: FM Priority: Low Criticality: Low Systems: 0 ICAO: 1 BRM SRM TRM PRM DRM	[CM-DEXPL] Disseminate Execution Plan Actors: CM Priority: Low Criticality: Low Systems: 0 ICAO: 2 BRM SRM TRM PRM DRM	
[FC-RCPLA] Restructure Capacity Limited Airspace Actors: FM Priority: Low Criticality: Low Systems: 0 ICAO: 1 BRM SRM TRM PRM DRM	[CM-ADPCP] Analyze demand and projected capacity Actors: CM Priority: Medium Criticality: Low Systems: 1 ICAO: 8 BRM SRM TRM PRM DRM	

Source: "Enterprise Architecture V2.0", produced by the JPDO EAED, dated 22 June 2007.

Air Navigation Support FEA RM Alignment

Figure 52: Air Navigation Support FEA RM

Air Transportation

Air Navigation Support

- Airspace Security Operations
- Capacity Management
- Flow Contingency Management

The Air Navigation Support Segment provides the short and long-term planning aspect for ensuring the safe, secure, and efficient access to the airspace. As depicted in figure 13, this segment is primarily categorized under the Air Transportation Line of Business. It describes the activities associated with the prevention and countering of external attacks on aircraft and other airborne vehicles, the planning and design of the airspace, and the monitoring of current airspace conditions to reallocate if necessary. The following table further describes the Air Navigation Support Segment and identifies how each activity aligns to the other architectural layers of the NextGen EA Reference Architecture.

Source: "Enterprise Architecture V2.0", produced by the JPDO EAED, dated 22 June 2007.

Air Navigation Support Activity Model (OV-5)

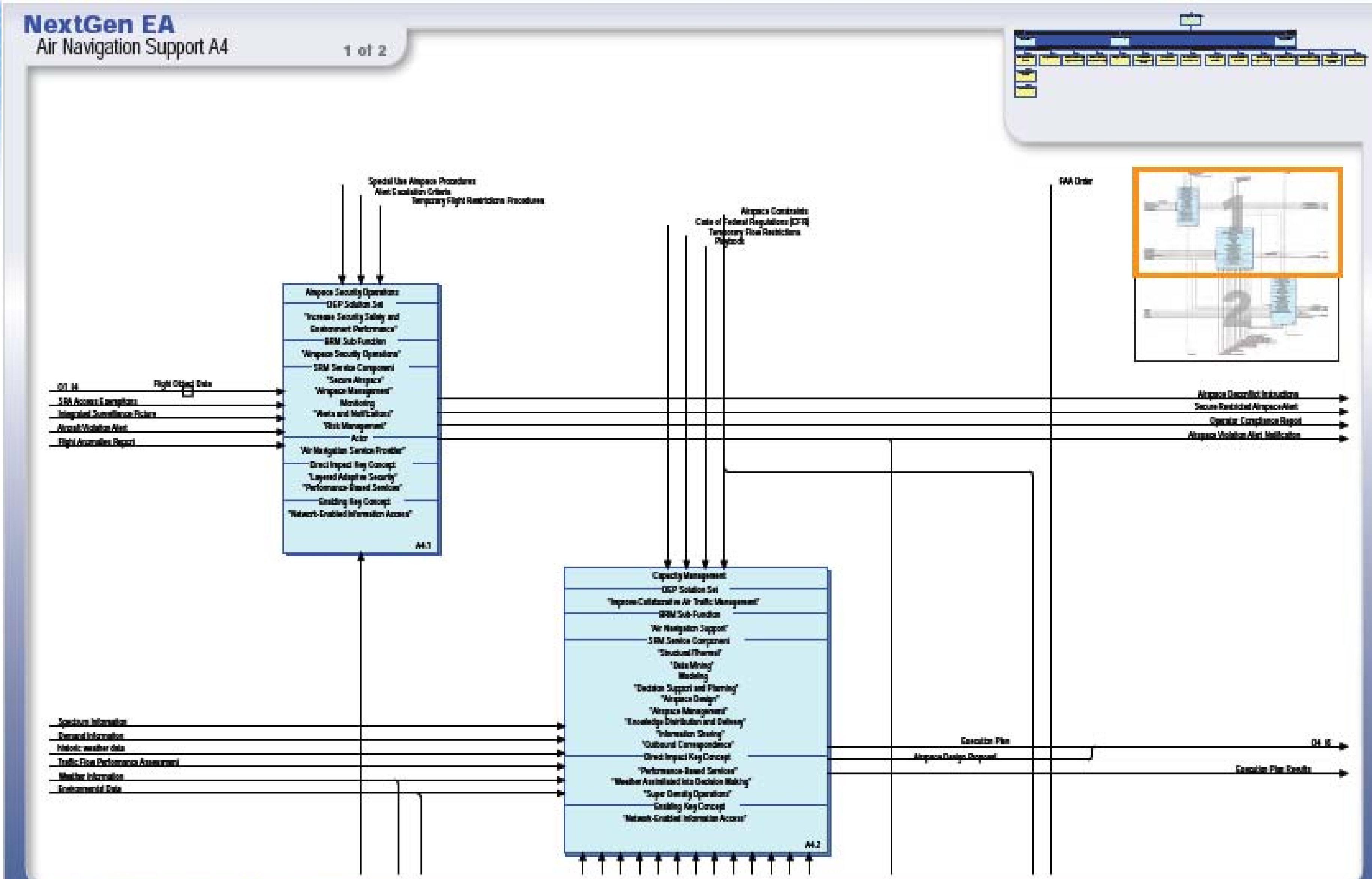
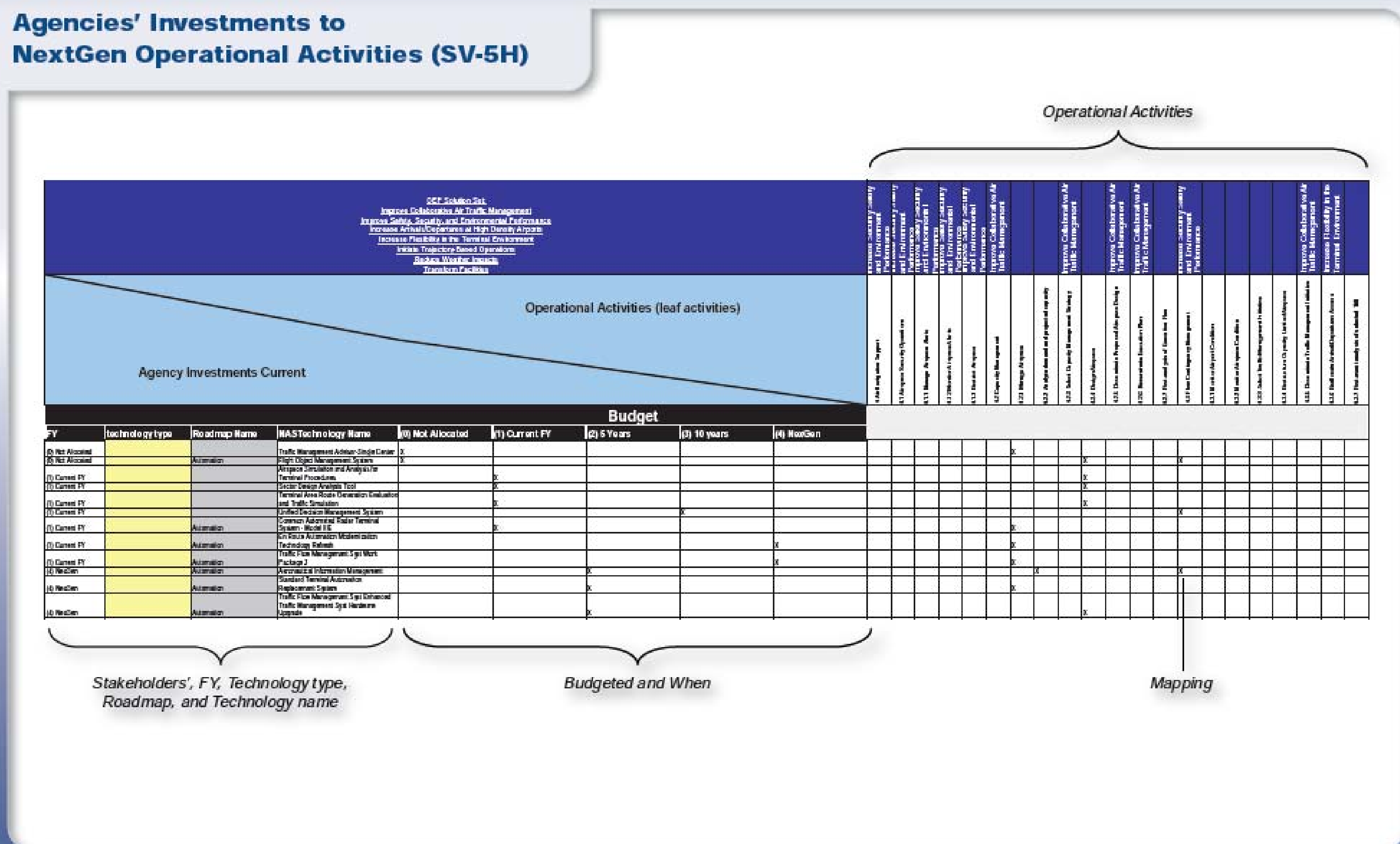


Figure 53 - 4 Air Navigation Support Activity Model Diagram

Source: "Enterprise Architecture V2.0", produced by the JPDO EAED, dated 22 June 2007.

Use of Operational Activity to Stakeholder Investment Traceability Matrix (SV-5 Hybrid)



Source: "Enterprise Architecture V2.0", produced by the JPDO EAED, dated 22 June 2007.

Use of the OMB Federal Transition Framework (FTF) in Support of the NextGen EA

FTF As Alignment Mechanism

The FTF is a catalog of government-wide initiatives, providing agencies with an information source to support EA planning and improve the efficiency and effectiveness of investments to realize service improvements and cost savings. The JPDO envisions the NextGen ATS FTF catalog item as a mechanism for ensuring that the relevant NextGen segments and capabilities of the NextGen EA are incorporated into the JPDO partner agency's respective target architectures, transition plans, and capital planning processes.

Source: "Joint Planning and Development Office – Program Management Plan V1.0 for the Enterprise Architecture and Engineering Division", produced by the JPDO EAED, dated 22 June 2007.

Benefits of Use of FTF in Support of NextGen EA Effort

- Increased partner EA agency alignment with NextGen EA
- Increased sharing and reuse of common, cross-agency business processes, service components, and technology standards
- Increased agency collaboration

Additionally, partner agencies can use the FTF as follows:

- Obtain consistent, complete, and detailed information about NextGen ATS more quickly to inform EA and capital planning efforts
- Make more informed decisions about investments
- Improve the effectiveness (i.e., performance) and efficiency (i.e., cost and schedule) of investments.

Source: "Joint Planning and Development Office – Program Management Plan V1.0 for the Enterprise Architecture and Engineering Division", produced by the JPDO EAED, dated 22 June 2007.

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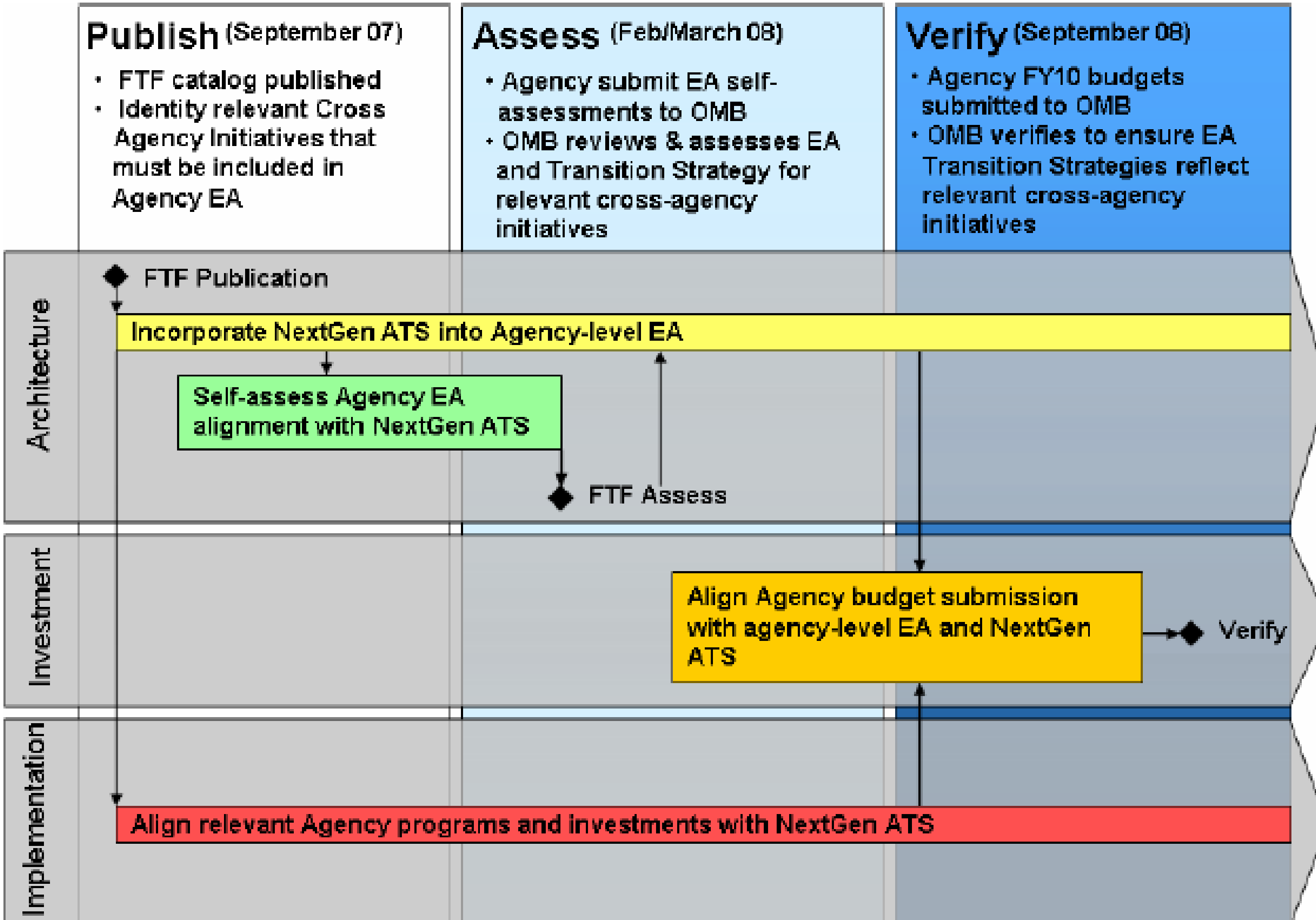
Usage of FTF in Support of NextGen EA



Source: "Joint Planning and Development Office – Program Management Plan V1.0 for the Enterprise Architecture and Engineering Division", produced by the JPDO EAED, dated 22 June 2007.

Usage of FTF in Support of NextGen EA (Cont'd)

	Scenario 1 Incorporate NextGen ATS into agency-level EA	Scenario 2 Self-assess EA alignment with NextGen ATS	Scenario 3 Align agency budget submission with agency-level EA and NextGen ATS	Scenario 4 Align agency IT programs with NextGen ATS
Agency Steps	• Review FTF Catalog to determine the applicability and scope of the NextGen ATS for your agency. • Update EA Program Plan to incorporate tasks to develop or update agency EA work products. • Update target EA to reflect NextGen ATS. • Conduct gap analysis between current and target architecture to identify gaps in current implementation of the NextGen ATS. • Update EA Transition Strategy to incorporate tasks, activities, and milestones to close gaps between the current and target architecture. • Submit revised EA work products and EA Transition Strategy to OMB with annual EA assessment submission package.	• Review OMB EA Assessment Framework and instructions to define requirements for the development and submission of agency EA self-assessment materials. • Refer to FTF Catalog to define NextGen ATS requirements for integration with agency EA and the EA Transition Strategy. • Conduct self-assessment of agency EA work products, EA Transition Strategy and implementation results relative to NextGen ATS requirements and assessment guidance. • Prepare self-assessment score and submission materials for NextGen ATS and incorporate into agency EA self-assessment package. • Submit agency EA self-assessment package to OMB.	• Develop IT investment portfolio in accordance with agency policy and procedures. Portfolio should reflect programs and projects defined by the EA Transition Strategy to implement agency EA including the NextGen ATS as described in the FTF Catalog. • Select projects to be included in the IT investment portfolio in accordance with agency policy and procedures. Select factors should include alignment with agency EA including the NextGen ATS. • Submit IT investment portfolio to OMB as part of the agency budget submission.	• Conduct regular control and evaluate actions as part of the CPIC process to review the alignment of current programs with agency EA and EA Transition Strategy including the NextGen ATS. • Develop recommendations and corrective actions to re-align programs with agency guidance and the NextGen ATS as described in the FTF Catalog. • Update individual program plans to incorporate recommendations and corrective actions. • Update IT investment portfolio to reflect recommendations and corrective actions.

Source: "Joint Planning and Development Office – Program Management Plan V1.0 for the Enterprise Architecture and Engineering Division", produced by the JPDO EAED, dated 22 June 2007.

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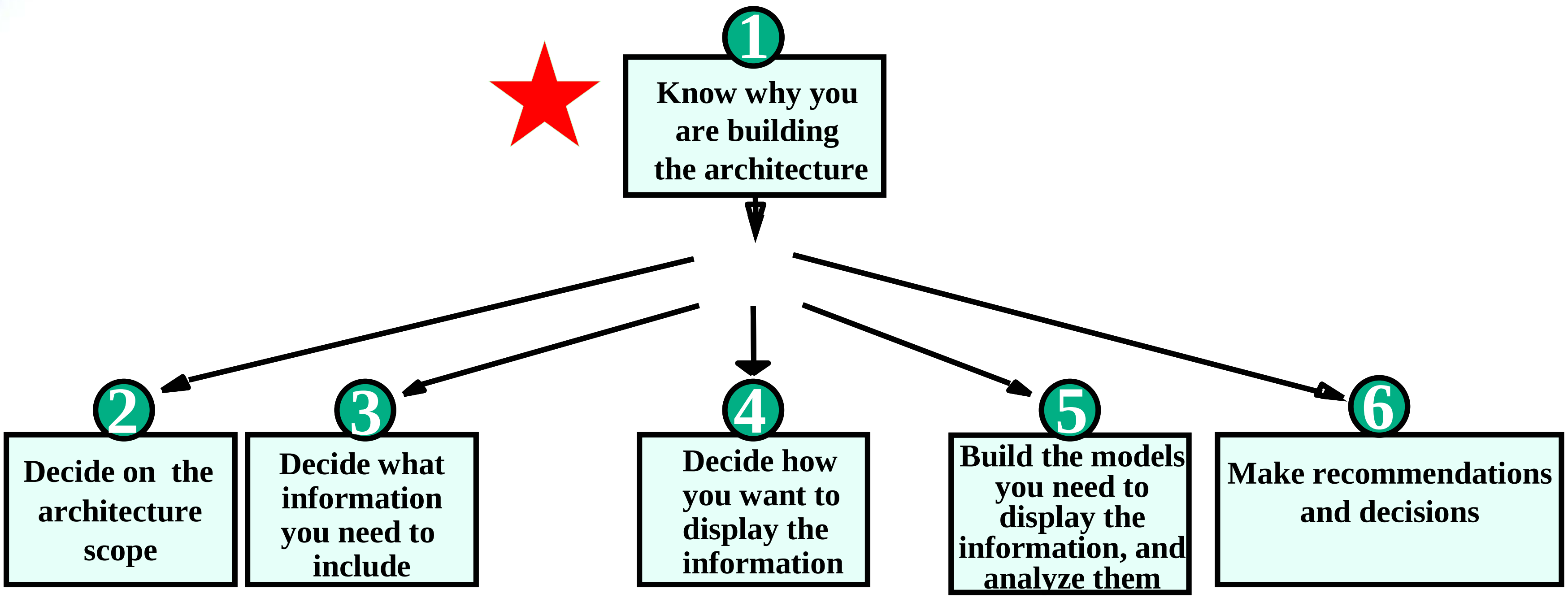
Lessons Learned

Before All Else, Articulate the Goals, Objectives and Purposes of the EA and Communicate to All Stakeholders



Clearly and explicitly articulate and communicate the purpose of the EA!

- Identify and clearly articulate the goals, objectives and purpose of the EA
- Articulate what issues need to be analyzed
- Specifically identify who needs the analysis
- What decisions need to made based on the analysis

Articulated and Effective Governance is the Foundation of the EA Effort

- **Governance**
  - Defines how decisions are made, who has the authority and who is accountable
  - Determines or exerts guiding influence over program policy, principles, architecture, strategy, and investment and prioritization
  - Determines process by which stakeholders articulate their interests and their input is absorbed
- **Governance Framework**
  - The plan and processes that describe the authority structures, roles, and responsibilities that must be implemented to effectively govern

An EA Program without articulated, effective governance places the entire EA program at significant risk

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Development and Use of a Communication Strategy

- **A "How to Engage" or "Rules of Engagement" Guide developed for use by external stakeholders for aligning their enterprise life cycle processes and EA related activities. This guidance would be a communication vehicle that would articulate:**
  - **The enterprise life cycle and schedule of the JPDO as it relates to the development and release of the EA, budget and R&D guidance.**
  - **The pertinent roles, bodies and associated governance structures that stakeholders will need to be cognizant of and interact with on an on-going basis.**

Additional Lessons Learned

- A substantive, explicitly articulated and meaningful Operational Concept Graphic (OV-1) is critical
- Issue of Utility – the importance of the Overview and Summary (AV-1)
  - Significant challenge faced by architects is the issue of utility of the EA
    - Identifying the communities who need the EA
    - Ensuring the info is in the proper form to be of use
- Federation DMZ
  - Need flexibility to manage multiple practices and levels of maturity i.e., need a DMZ
- Relating the EA to decision making
  - Coordinating Federal and Industry Business Case Practices
- Closing the Design
  - Issue of how to cope with long planning horizon i.e., target = 2025…

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Summary

Summary

- **NextGen is complex system with many public and private stakeholders that must smoothly, promptly, and capably integrate with the changes in the global air transportation system.**
- **EA is the foundation and means for articulating the vision and successfully integrating the activities of these diverse stakeholders in achieving NextGen**

Questions

Backup

An Enterprise Level Focus on NextGen

- **Transformation of the Nation's Air Transportation System requires:**
  - New policies **to create the right relationships and behaviors,**
  - Modernization **of infrastructure to reduce cost and set the stage for a new level of performance, and**
  - R&D **to create new functionality and capability that takes advantage of a modernized infrastructure**
  - **Engagement of** multiple entities **both public and private**

Enterprise Architecture provides the holistic structure to manage the transformation of the National Air Transportation System

Source: Briefing titled "The Next Generation Air Transportation System – EAED Products Status" by Dr. Edgar Waggoner, dated 16 May 2007.

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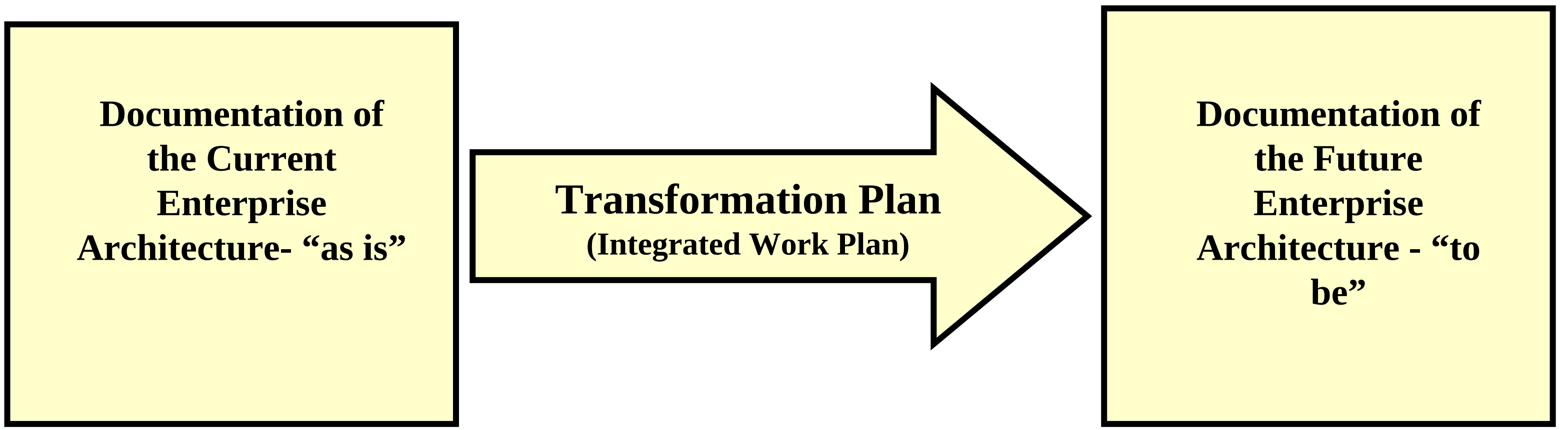
How will we use Enterprise Architecture?

- **Enterprise Architecture as a** documentation method **provides a modeling** framework **for the enterprise**



- **Enterprise Architecture enables** effective management **of NGATS planning and development by:**
  - **Supporting** change management **at the various levels**
  - **Identifying** integrated decisions **leading to requirements, agency commitments, and ultimately to** synchronized investments **to deliver the NGATS**
  - **Tracing** key dependencies **between capabilities, policies, operations, organizations, systems, and technologies**

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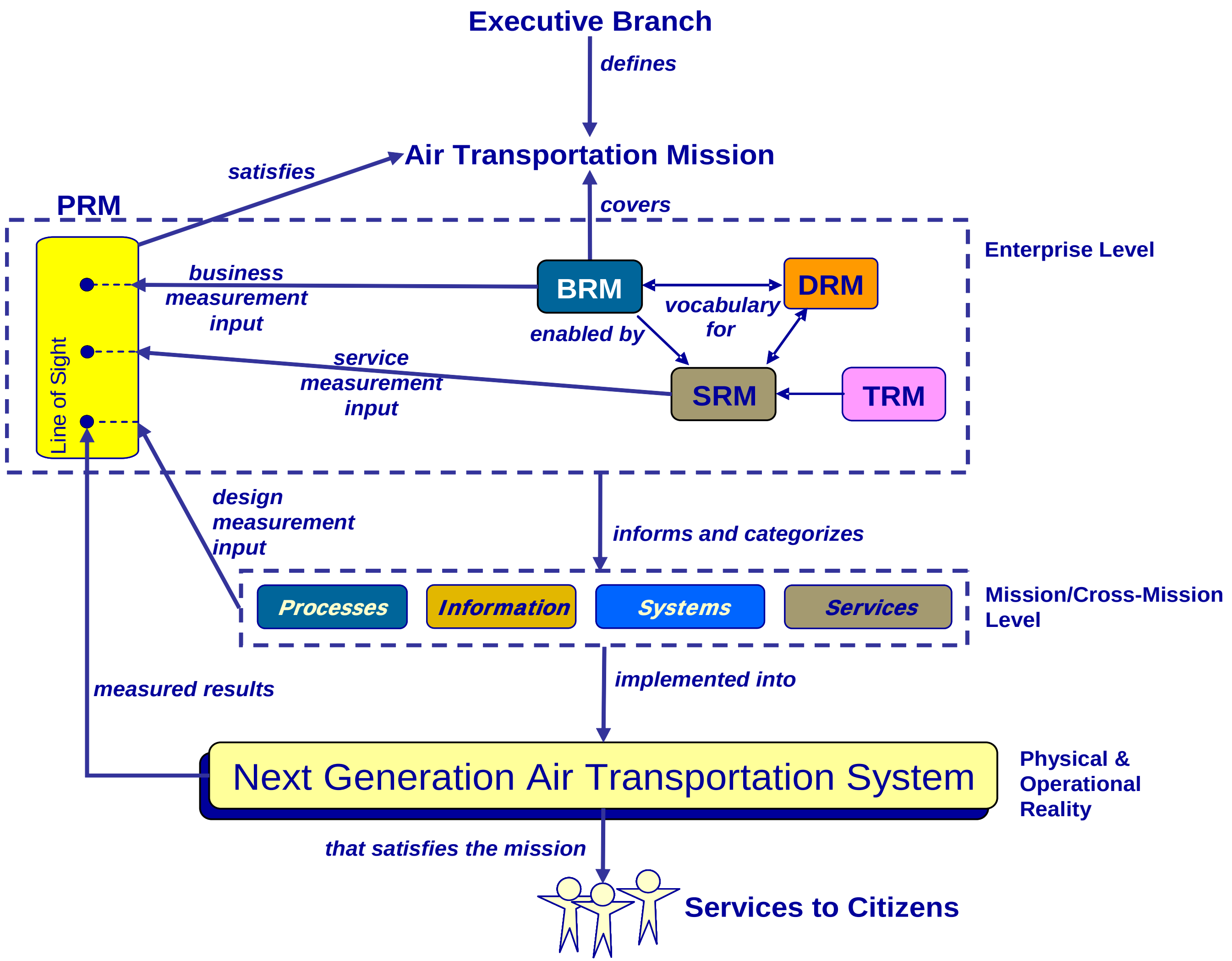
Source: Briefing titled “The Next Generation Air Transportation System – EAED Products Status” by Dr. Edgar Waggoner, dated 16 May 2007.

Use of OMB FEA Reference Models in Support of NextGen EA



Re-Forming the DoD Acquisition Process

A Systems Engineering Approach

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22 OCT 2007

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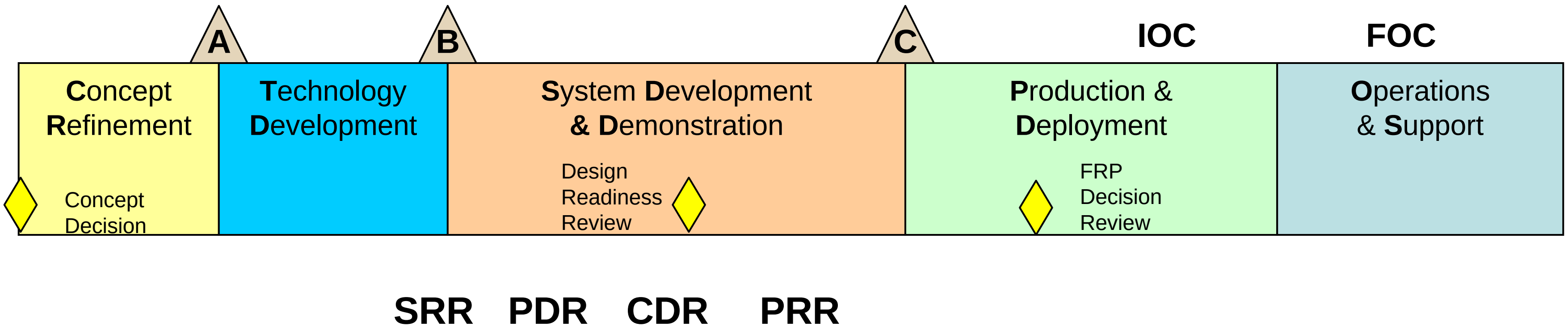
OVERVIEW

- **CURRENT DoD 5000 MODEL**
- **FAA CERTIFICATION PROCESS MODEL**
- **PROPOSED AIRCRAFT ACQUISITION MODEL**

Current DoD 5000 Model
All Systems



Current DoD 5000 Model
All Systems

- **ADVANTAGES**
  - Framework allows flexibility
  - Easily tailored for specific program requirements
  - Allows for Technology Development prior to SDD phase

- **DISADVANTAGES**
  - Most risk is on acquisition agency for development
  - Capability and certification requirements are not integrated
  - Certifications can have significant impact on program cost and schedule

Commercial Development Process

FAA Certification Process

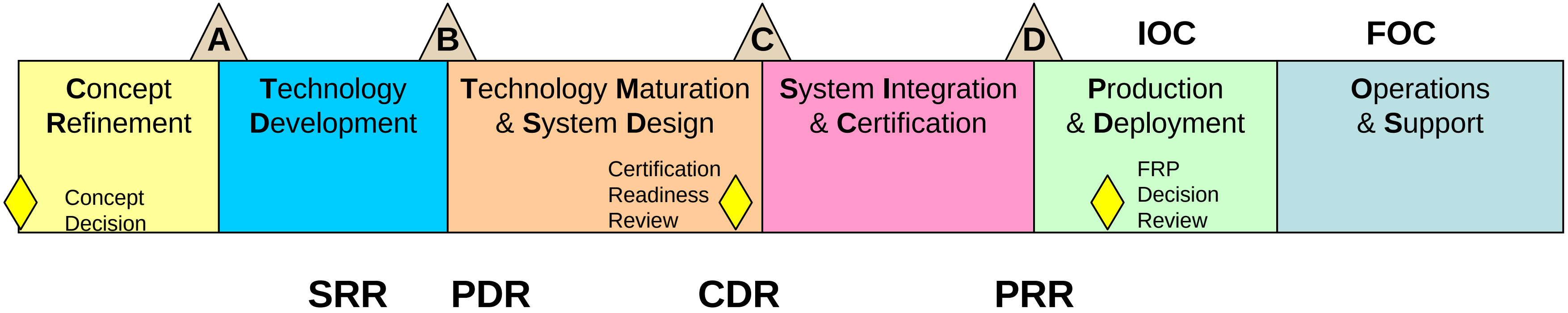
- FAA process is regulatory - Type certification requirements are must dos
  - In DOD airworthiness requirements are not even Key Performance Parameters
- Customers involved in creating requirements - Notice of Proposed Rulemaking
  - No buy-in by customers on DoD airworthiness criteria
- Type cert board establishes criteria up-front
  - Includes compliance method
  - Done prior to design and test phase
- Cost/schedule of compliance is better known up-front
  - DoD criteria are not fully agreed to until after cost established
- Type certification drives significant cost to a commercial program
  - AF 516B drives cost but those costs are unknown at contract award
- There is a known process in place to certify components - Technical Standards Orders Database
- Independent organization verifies compliance

FAA Certification Process

- **ADVANTAGES**
  - Proven safety track record
  - Well understood cost and schedule
  - Total requirements set known at program approval
  - Early planning for validation minimizes risk

- **DISADVANTAGES**
  - Little consideration for cost of ownership
  - All development risk is on the airframe developer
    - Design influenced by available, mature technology

Proposed Model
Aircraft Systems



Proposed Model
Aircraft Systems

- Milestone A - Technology Development
  - Entry criteria
    - Technology Development Strategy
    - Initial Capabilities Document
  - Contract type – Cost Plus/Award Fee
  - Timeline/Schedule
  - Integrated Risk Assessment

Proposed Model
Aircraft Systems

- Milestone B - Technology Maturation and System Design
  - Entry criteria
    - SRR
    - Capabilities Description Document
    - Certification Plan
  - Contract type – Cost Plus/Incentive or Award Fee
  - Timeline/Schedule
  - Integrated Risk Assessment

Proposed Model
Aircraft Systems

- Milestone C - System Integration and Certification
  - Entry criteria
    - CDR
    - Capabilities Production Document
  - Contract type – Fixed Price/Incentive Fee
  - Fixed Timeline/Schedule
  - Integrated Risk Assessment

Proposed Model
Aircraft Systems

- Milestone D - Production
  - Entry criteria
    - PRR
    - System Certification
    - Successful Initial Operational Test & Evaluation
  - Contract type – Fixed Price/Incentive Fee
  - Timeline/Schedule
  - Integrated Risk Assessment

Proposed Model
Aircraft Systems

- **ADVANTAGES**
  - Integrates systems engineering events with acquisition milestones
  - Integrates capability and certification requirements
  - Utilizes a known development/certification process
  - Allows risk-based management of resources
  - Provides Time Certain certification – similar to FAA
  - Similarity to FAA cert encourages broader business base

- **DISADVANTAGES**
  - Increases the number of Defense Acquisition Boards

Summary

- Current acquisition process has room for improvement
- Requirements and acquisition processes need to be better integrated
- Program risk can be reduced through better alignment of acquisition milestones and systems engineering events

Acquisition M&S Master Plan Implementation Status

NDIA Systems Engineering Conference
San Diego, California
October 23, 2007

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Acquisition M&S Master Plan Structure

Department of Defense

Acquisition Modeling and Simulation Master Plan

Issued by the

DoD Systems Engineering Forum

April 17, 2006

1

- **Foreword**
- **Introduction**
  - **Purpose**
  - **Vision**
  - **Scope**
- **Objectives (5)**
- **Actions (40)**
  - **Action**
  - **Rationale** (why it's needed)
  - **Discussion** (implementation guidance)
  - **Lead & supporting organizations**
  - **Products** (what is expected)
  - **Completion goal (year)**
- **Execution Management**

http://www.acq.osd.mil/ds/se/publications/AMSMP_041706_%20FINAL2.pdf

Five Objectives, 40 Actions

Objective 1	Objective 2	Objective 3	Objective 4	Objective 5
Provide necessary policy and guidance	Enhance the technical framework for M&S	Improve model and simulation capabilities	Improve model and simulation use	Shape the workforce
1-1 M&S management 1-2 Model-based systems engineering & collaborative environments 1-3 M&S in testing 1-4 M&S planning documentation 1-5 RFP & contract language 1-6 Security certification	2-1 Product development metamodel 2-2 Commercial SE standards 2-3 Distributed simulation standards 2-4 DoDAF utility a) DoDAF 2.0 Systems Engineering Overlay b) Standards for depiction & interchange 2-5 Metadata template for reusable resources	3-1 Acquisition inputs to DoD M&S priorities 3-2 Best practices for model/sim development 3-3 Distributed LVC environments a) Standards b) Sim/lab/range compliance c) Event services 3-4 Central funding of high-priority, broadly-needed models & sims a) Prioritize needs b) Pilot projects c) Expansion as warranted	4-1 Help defining M&S strategy 4-2 M&S planning & employment best practices 4-3 Foster reuse a) Business model b) Responsibilities c) Resource discovery 4-4 Info availability a) Scenarios b) Systems c) Threats d) Environment 4-5 VV&A a) Documentation b) Risk-based c) Examination 4-6 COTS SE tools 4-7 M&S in acqn metrics	5-1 Definition of required M&S competencies 5-2 Harvesting of commercial M&S lessons 5-3 Assemble Body of Knowledge for Acqn M&S 5-4 M&S education & training a) DAU, DAG & on-line CLMs b) Conferences, workshops & assist visits 5-5 MSIAC utility

Key

Broader than Acqn

Partially broader

Objective 1: Provide Necessary Policy & Guidance

1-1. Provide effective, persistent DoD-wide M&S management to address cross-cutting M&S issues, coordinate actions

Lead: OUSD(AT&L) **Support:** OUSD(AT&L)/DS(SSE), OUSD(P&R), OUSD(C)/PA&E, etc.

Products: Revised DoDD 5000.59 (M&S Management) (& DoDI) with clearer responsibilities, revised EXCIMS (MSSC) membership, SOP for EXCIMS (MSSC) processes, a refocused DMSO (MSCO)

Completion goal: 2006

- **New DoD M&S management structure in place; effectiveness in doubt**
- **No acquisition community leadership role (Tri-chair) on MSSC**
- **New DoD Directive 5000.59 finally released Aug 07, but defining key responsibilities and processes awaits a DoDI**
- **Current project selection process is inconsistent, inefficient, and wastes $**
- **Action completion is overdue (2006)**

Next Steps:

- **Continue to argue for an SSE leadership role on M&S SC**
- **Push for a DoDI on M&S management**
- **Propose an alternative DoD M&S planning approach**

Objective 1: Provide Necessary Policy & Guidance

1-2. Promote model-based systems engineering (MBSE) and M&S-enabled collaborative environments, at both the program and joint capability level

Lead: OUSD(AT&L)/DS(SSE); **Support:** Components

Products: Revised guidance in DAG

Completion goal: 2007

- **Current DAG mentions collaborative environments 14 times, simulation-based testing once, SBA twice, and MBSE not at all.**
- **Programs/companies often claim collaborative environments, but only partial**
- **MBSE a prominent part of INCOSE's SE Vision 2020; MBSE Initiative underway**
- **Increasing industry use of MBSE concept & tools**
- **AMSWG (SSE) submitted new DAG language**

Next steps:

- **Nothing further now. Reconsider if submitted DAG language is rejected.**

Objective 1: Provide Necessary Policy & Guidance

1-3. Establish policy and guidance on appropriate use of M&S to plan tests, to complement system live tests, and to evaluate joint capabilities

Co-leads: OUSD(AT&L)/DS, ODOT&E; **Support:** Components

Products: Revised policy and guidance in DoDI 5000.2 and DAG

Completion goal: 2007

- **Concepts accepted, but little practical guidance regarding criteria for M&S use**
- **JMETC launched but many challenges ahead, including policy**
- **Increased discussion of M&S support to testing in latest submission to M&S section of DAG**
- **NDIA DT&E Cmte is coordinating development of industry recommendations for changes to T&E portions of DoDD 5000 series (& possibly CJCSI 3170.01)**

Next steps:

- **NDIA M&S Cmte participate in DT&E Cmte effort**
- **Track JMETC policy development, react as required**
- **Draft/submit changes to T&E portions of DoDI 5000.2 & DAG**

Obj. 1: Provide Necessary Policy & Guidance (cont.)

1-4. Establish policy to require documented M&S planning at the joint capability & program levels as part of the Systems Engineering Plan, T&E Strategy and T&E Master Plan

Co-leads: OUSD(AT&L)/DS(SSE), ODOT&E; **Support:** Components

Products: Revised policy and guidance in DoDI 5000.2, DAG, and DOT&E TEMP Planning Guidance

Completion goal: 2007

- **AMSWG (SSE) submitted revised language to DoD 5000.2, DAG language and SEP Preparation Guide**
- **Partial acceptance of SEP language thus far; other TBD**
- **No action this far regarding language in TEMP Plng Guidance**

Next steps:

- **Draft/submit language for TEMP Planning Guidance**

Obj. 1: Provide Necessary Policy & Guidance (cont.)

1-5. Establish M&S-related guidelines for solicitations, source selections, and contracting.

Lead: OUSD(AT&L)/DS(SSE); **Support:** OUSD(AT&L)/DPAP, ODOT&E, Components

Products: Sample language in DoD publications (e.g., DAG, SEP Preparation Guide, Contracting for Systems Engineering Guidebook) regarding M&S requirements, data rights, and the responsibilities and liabilities of parties regarding sharing and reuse

Completion goal: 2007

- **Solicited inputs from AMSWG members and industry (through NDIA M&S Cmte)**
- **AMSWG (SSE) submitted DAG language regarding source-selection criteria**
- **Presentation at Oct 07 NDIA Systems Engineering Conference**

Next steps:

- **Further refinement and vetting of proposed guidance**
- **Synthesize best language & submit to DAG (update), SEP Preparation Guide, and Contracting for Systems Engineering Guidebook**

Obj. 1: Provide Necessary Policy & Guidance (cont.)

1-6. Ensure practical guidelines for information assurance certification and accreditation of M&S federated networks falling under multiple Designated Accreditation Authorities (DAAs)

Lead: OASD(NII); **Support:** OUSD(AT&L)/DS(SSE), OUSD(I), NSA

Products: Proven, practical guidelines published in DAG and DoD 8500.2-H, per DoDI 8500.2 “Information Assurance Implementation,” Feb 6, 2003

Completion goal: 2007

- **NII has published DoDI 8500.2, but AMSWG questions adequacy**
- **AMSWG-NII discussions underway; NII reviewing NAVAIR procedures for suitability in DAG**
- **Unlikely to complete in 2007**

Next steps:

- **Continue to ground discussions in practical experience; push NII as warranted**
- **Draft, vet, and submit DAG language**

Objective 2: Enhance the Technical Framework for M&S

2-1. Develop a product development information metamodel & associated metadata extensions to the DoD Discovery Metadata Specification

Lead: OUSD(AT&L)/DS(SSE); **Support:** OASD(NII), Components
Products: Revised DDMS; revised guidance in DAG.
Completion goal: 2008

- **JSF has developed a metamodel specification and provided it to MSCO**
- **It seems unlikely MSCO M&S COI Discovery Metadata project will address anything beyond discovery metadata**
- **JSF hopes to enlist MSCO (Scrudder) assistance to evolve its metamodel**

Next steps:

- **Explore PA&E interest to make this a "blue" effort**
- **Cooperate with JSF in efforts to revise/extend metamodel**

Objective 2: Enhance the Technical Framework for M&S

2-2. Support development of open commercial and non-proprietary standards for systems engineering, such as OMG's Systems Modeling Language (SysML) and ISO Standard 10303 AP-233

Co-leads: OUSD(AT&L)/DS(SSE); DoD CIO **Support:** OASD(NII), DLA, OUSD(AT&L), **Products:** Standards suitable for use by DoD

Completion goal: 2007

- SysML v1.0 issued as an "available standard;" v 1.1 minor revision late 2008
- Increasing usage & teaching of SysML; major subject at INCOSE, NDIA
- Navy M&S Standards Steering Group has proposed SysML as a standard
- AP-233 SE data interchange standards being released incrementally
- COTS System Engineering tools incorporating SysML and AP-233
- Nothing yet submitted to DoD Standardization Program

Next steps:

- Track SysML and AP-233 implementations, publicize results
- Investigate DoD Standardization Program process; submit SysML and AP-233

Objective 2: Enhance the Technical Framework for M&S

2-3. Establish a forum to clarify the characteristics and application of various distributed simulation standards (ALSP, DIS, HLA, SI3, TENA, etc.) and examine opportunities for convergence

Lead: OUSD(AT&L) **Support:** OUSD(AT&L)/TRMC & DS(SSE), ODOT&E, Components

Products: (1) Information on strengths & weaknesses of the various standards; (2) agreement on policy and/or guidance on the use of distributed simulation standards; (3) a way ahead regarding distributed simulation standards

- **Completion goal:** 2007

- **MSSC-funded LVCAR Project underway, but behind schedule**
- **SE Forum is interested, had taken one briefing**
- **AMSWG members engaged in this effort and tracking progress; concern on requirements definition**

Next steps:

- **No additional steps needed**

Obj. 2: Enhance the Technical Framework for M&S (cont.)

2-4. Improve the utility of the DoD Architecture Framework (DoDAF) for acquisition

~~2-4(a) Develop Systems Engineering Overlay (profile) for DoDAF v2.0~~

~~**Lead:** OUSD(AT&L)/DS; **Support:** OASD(NII), Components~~

~~**Products:** Acquisition Overlay for DoDAF v2.0~~

~~**Completion goal:** 2006~~

2-4(b) Support development of open commercial standards for the depiction and interchange of DoDAF-compliant architectures

Lead: OASD(NII) **Support:** OUSD(AT&L)/DS(SSE)

Products: Published standards suitable for adoption by DoD in DoDAF 2.0; revised guidance in DAG

Completion goal: 2007

- **2-4(a): Overlay concept has been dropped, so this action is OBE**
- **2-4(b): OMG's UPDM (UML Profile for DoDAF/MODAF) nearing finalization**
- **SE Forum just beginning to appreciate the value of DoDAF**
- **ASD(NII) is attempting to make DoDAF v2.0 more useful for acquisition**
- **Acquisition Community participation in DoDAF WG curtailed**

Next steps:

- **Increase acquisition community involvement in DoDAF WG, including pushing for commercial standards for architecture data exchange**
- **Revise AMSMP to eliminate Action 2-4(a)**

Obj. 2: Enhance the Technical Framework for M&S (cont.)

2-5. Establish a standard template of key characteristics (metadata) to describe reusable M&S resources

Lead: OUSD(AT&L) **Support:** OUSD(AT&L)/DS(SSE) & TRMC, OASD(NII), ODOT&E, Components

Products: Published standard template; usage guidance in DAG

Completion goal: 2007

- **MSCO M&S COI Discovery Metadata project underway to address this**
- **Usage guidance in DAG will follow downstream, after template definition**

Next steps:

- **Support MSCO metadata project by participating in reviews**
- **Investigate OMG's Reusable Asset Specification (RAS)**

Objective 3: Improve Model & Simulation Capabilities

3-1. Establish a process to ensure acquisition needs are reflected in DoD M&S priorities

Lead: OUSD(AT&L) **Support:** OUSD(AT&L)/DS(SSE), ODOT&E, DOD CIO, Components

Products: A method to capture and prioritize acquisition needs.

Completion goal: 2007

- **AMSWG has successfully obtained M&S SC funding for several projects**
- **MSSC funding has gone to projects of questionable value, perhaps because AMSWG was too modest in what it proposed**
- **Acquisition M&S still does not have an effective voice in other DoD funding arenas that affect M&S capability, such as other S&T and DARPA**

Next steps:

- **Investigate DoD S&T planning process to identify entry points**
- **Build list of acquisition M&S S&T needs**

Objective 3: Improve Model & Simulation Capabilities

3-2. Define and foster best practices for efficient development and evolution of credible M&S tools, incorporating user-defined requirements, a systems engineering approach, and appropriate verification & validation

Lead: OUSD(AT&L); **Support:** OUSD(AT&L)/DS(SSE), ODOT&E, DOD CIO, Components

Products: Best practices publication, available via MSIAC, DTIC, etc.; DAG guidance to use

Completion goal: 2008

- **No significant effort thus far**
- **Expect some insights from other best practices solicitation (Action 4-2)**

Next steps:

- **Conduct literature search; synthesize best practice**

Obj 3: Improve Model & Simulation Capabilities (cont.)

3-3. Enable readily-available distributed live-virtual-constructive environments, leveraging related initiatives

3-3(a) Establish DoD-wide standards for distributed environments

Lead: OUSD(AT&L); **Support:** OUSD(AT&L)/TRMC & DS(SSE); ODOT&E; DOD CIO, Components

Products: Published standard; DODI (# TBD) policy to use

Completion goal: 2008

3-3(b) Make candidate simulations, labs and ranges compliant with these standards

Lead: Components; **Support:** OUSD(AT&L)/DS(SSE) & TRMC, ODOT&E

Products: A larger collection of simulations, labs, and ranges ready to be employed in distributed events

Completion goal: 2010

3-3(c) Ensure availability of services to help plan and conduct events

Lead: Components; **Support:** OUSD(AT&L), OUSD(AT&L)/TRMC, DISA

Products: Fee-based technical services to help users (e.g., PMs, Capability Managers, OTAs) plan and conduct distributed events

Completion goal: 2009

- **LVC Architecture Roadmap project underway**
- **Nothing begun on other standards (object models, data exchange, etc.)**

Next steps:

- **Investigate use of SysML in Federation Development and Execution Process (FEDEP)**

Obj 3: Improve Model & Simulation Capabilities (cont.)

3-4. Centrally fund and manage the development of high-priority, broadly-needed M&S tools

3-4(a) Identify and prioritize broadly-needed M&S tools

Lead: OUSD(AT&L); **Support:** OUSD(AT&L)/DS(SSE); ODOT&E, DOD CIO, Components

Products: Prioritized list of common M&S tool needs

Completion goal: 2007

3-4(b) Conduct one or more pilot projects to develop new M&S tools or update existing ones to ~~meet these needs~~ prove this mngmt concept

Lead: OUSD(AT&L); **Support:** OUSD(AT&L)/DS(SSE), Components

Products: Proof of concept for managing the development/evolution of M&S tools to meet broadly-shared needs

Completion goal: 2008

3-4(c) Expand the scope of central M&S tool management as warranted by pilot project results and the list of common M&S needs

Lead: OUSD(AT&L); **Support:** OUSD(AT&L)/DS(SSE), ODOT&E, Components

Products: Capability to provide broadly-needed M&S tools in a more responsive and cost-effective way.

Completion goal: 2011

- **AMSWG submitted 3-4(b) pilot proposal, as one of the top 5 acquisition projects for MSSC FY08 funding**

Next steps:

- **Conduct central model management pilot project**

Objective 4: Improve Model & Simulation Use

4-1. Provide potential acquisition M&S users the knowledge needed to formulate an effective M&S strategy via ready access to M&S expertise and information about M&S capabilities and gaps, reusable resources, lessons-learned, etc.

Lead: OUSD(AT&L); **Support:** OUSD(AT&L)/DS(SSE)

Products: Revised guidance in DAG; improved knowledge base in MSIAC; assist visits (e.g., by OUSD(AT&L)/DS(SSE))

Completion goal: 2008

- **Revised guidance submitted to DAG**
- **SSE M&S Cell assisting as able, but not widely advertised**
- **No other Components offering assistance**
- **5-1 Education project Identified many M&S Bodies of Knowledge (BoKs) that may offer useful information**

Next steps:

- **Advertise and expand assist visits**
- **Improve MSIAC expertise regarding M&S in acquisition (Action 5-5)**

Objective 4: Improve Model & Simulation Use

4-2. Define and disseminate best practices for disciplined M&S planning & employment

Lead: OUSD(AT&L)/DS(SSE), **Support:** OUSD(AT&L), Components
Product: Revised best practices guidance in DAG and MSIAC
Completion goal: 2007

- **High-level discussion included in “M&S for Systems Engineering” CLM**
- **Expanded discussion submitted in recent DAG revision**
- **M&S Planning and Employment Best Practices solicitation completed in April**

Next steps:

- **Synthesize best practice, conduct AMSWG & NDIA reviews**

Obj. 4: Improve Model & Simulation Use (cont.)

4-3. Facilitate the sharing of reusable resources

4-3(a) Establish a DoD-wide business model for compensating providers of reusable M&S resources (e.g., information, software, services)

Lead: OUSD(AT&L); **Support:** OUSD(AT&L)/DS(SSE), OUSD(P&R), OUSD(C)/PA&E, Components

Product: Documented business model; revised policy and/or guidance in DoD 5000 series & DAG

Completion goal: 2007

- **MSSC-funded M&S Resource Reuse Business Model project underway**

Next steps:

- **No further action needed yet**

Obj. 4: Improve Model & Simulation Use (cont.)

4-3. Facilitate the sharing of reusable resources

4-3(b) Establish DoD policy and/or guidance regarding responsibilities to share, protect and properly use M&S information, tools, and data

Co-Leads: OASD(NII), OUSD(AT&L), USD(I); **Support:** OUSD(AT&L)/DS(SSE) & DPAP, OUSD(P&R), OUSD(C)/PA&E, Components

Product: Revised policy and/or guidance in various issuances (e.g., DoD 5000 series, DAG, contracting guidance)

Completion goal: 2008

- **Drafted and submitted DAG language**
- **M&S Resource Reuse Business Model project may make recommendations on this subject**

Next steps:

- **Draft language for contracting guide**
- **(Hold-off submitting a 5000 change)**

Obj. 4: Improve Model & Simulation Use (cont.)

4-3. Facilitate the sharing of reusable resources

4-3(c) Enhance the means (e.g., directory service, registries, bulletin boards) to discover the existence of reusable resources required for M&S and contact information

Lead: OUSD(AT&L) **Support:** OUSD(AT&L)/DS(SSE), OUSD(P&R), OUSD(C)/PA&E, Components

Product: A better way to discover reusable resources. Re-orientation and integration of various DoD M&S resources repositories.

Completion goal: 2007

- **Al Shaffer has directed MSCO to develop a "reliable repository"; we have objected based on prerequisites; project is proceeding**
- **Actions 2-5 is a prerequisite to 4-3(c)**

Next steps:

- **Monitor MSCO project; no further action needed now**

Obj. 4: Improve Model & Simulation Use (cont.)

4-4. Define the types of information DoD organizations shall make available to others with a clearance and valid need to know and the processes to obtain them (per reuse business model). The process to obtain information should include an efficient mechanism for industry to request government data with specific "need to know" outside a specific contract environment**.**

4-4(a) Scenario data

Lead: OUSD(AT&L) **Support:** OCJCS(J8), OUSD(C)/PA&E, DIA, Components
Product: Approved scenarios and process to obtain
Completion goal: 2007

4-4(b) System-related data

Lead: OUSD(AT&L)/DS(SSE); **Support:** ODOT&E, Components
Product: Process to obtain authoritative system data (characteristics and performance, interactions, interfaces, logistic support, etc.) documented in the DAG and appropriate OASD (NII) policy documents.
Completion goal: 2008

4-4(c) Threat data

Lead: DIA; **Support:** OUSD(AT&L); OUSD(AT&L)/DS(SSE), ODOT&E, and Components
Product: Authoritative threat data and process to obtain
Completion goal: 2007

4-4(d) Natural environment data

Lead: DoD Natural Environment MSEAs; **Support:** OUSD(AT&L), OUSD(AT&L)/DS(SSE), Components
Product: Authoritative natural environment data and process to obtain
Completion goal: 2007

Action 4-4 Assessment

- Acquisition Support Division of DIA has briefed AMSWG and NDIA M&S Cmte on its support to acquisition programs
- MSIC has briefed NDIA M&S Cmte on TMAP program and provided instructions on how to request TMAP models
- Draft DAG language discusses threat data sources and traceability
- No method exists "for industry to request government data with specific 'need to know' outside a specific contract environment"
- MSSC-funded Environmental Scenario Generator project underway
- No progress regarding sharing U.S. system data
- Joint Rapid Scenario Generation (JRSG) and Joint Data Alternatives (JDA) projects advertise they will address all the Action 4-4 info needs; time will tell

Next steps:

- Participate in JRSG and JDA effort as resources permit
- Investigate data sharing polices of OSD, JCS, and other Components
- Investigate JSC, PAE, & Service scenario data availability & access
- Draft add'l DAG language on all data types (interim prior to JRSG /JDA)
- Use NDIA M&S Cmte to assess seriousness of no-contract data access issue

Obj. 4: Improve Model & Simulation Use (cont.)

4-5. Foster cost-effective VV&A

4-5(a) Require DoD-wide standardized documentation of VV&A

Lead: OUSD(AT&L); **Support:** OUSD(AT&L)/DS(SSE), ODOT&E, Components

Products: Revised policy in DODI 5000.2 and 5000.61; revised guidance in DAG

Completion goal: 2007

- **MSCO project underway**
- **AMSWG concern that draft MSSC's "DoD M&S Strategic Vision" call for "practical verification, validation, and accreditation guidelines <u>that vary by application area</u>" (emphasis added) will undermine VV&A.**

Next steps:

- **Monitor MSCO project**
- **Actively participate in any DoDI 5000.61 update**

Obj. 4: Improve Model & Simulation Use (cont.)

4-5. Foster cost-effective VV&A

4-5(b) Develop risk-based methodology and associated guidelines for VV&A expenditures

Lead: OUSD(AT&L); **Support:** OUSD(AT&L)/DS(SSE), Components

Products: Updated DoDI 5000.61; revised policy and guidance in DoDI 5000.2 and DAG

Completion goal: 2007

- **MSCO project underway**

Next steps:

- **Monitor MSCO progress developing risk-based VV&A guidelines, take action as necessary**

Obj. 4: Improve Model & Simulation Use (cont.)

4-5. Foster cost-effective VV&A

4-5(c) Examine a program's VV&A when M&S informs major acquisition decisions and unambiguously state the purpose, key assumptions and significant limitations of each model/simulation when results are presented.

Lead: OUSD(AT&L)/DS(SSE) **Support:** DoD Components
Products: Guidance & training for oversight personnel; updates to DAG Chaps 4, 9
Completion goal: 2007

- **Submitted DAG language on VV&A examination**
- **SSE M&S Cell has given initial briefing to OUSD(A&T)/SSE/AS**
- **No other Component activities underway**

Next steps:

- **Broaden teaching on VV&A examination**

Obj. 4: Improve Model & Simulation Use (cont.)

4-6. Assess the use of COTS systems engineering tools (modeling environments) for collaborative architecture development

Lead: OUSD(AT&L)/DS(SSE); **Support:** OASD(NII), Components

Products: Revised guidance in DAG; enhanced M&S body of knowledge for dissemination

Completion goal: 2007

- **SysML and AP-233 already proving utility**
- **UPDM nearing finalization, can help with CADM AND DARS weaknesses**
- **NIST "Systems Engineering Tool Interoperability Plug-fest" underway**

Next steps:

- **Investigate use of SE tools for collaborative architecture development**

Obj. 4: Improve Model & Simulation Use (cont.)

4-7. Define and capture meaningful metrics for M&S utility in acquisition

Co-Leads: OUSD(AT&L), Dept. of the Navy **Support:** OUSD(AT&L)/DS(SSE), Components

Products: Metric definitions in DAG; methods to capture and submit data in DAG; data from individual projects in MSIAC, Body of Knowledge, etc.

Completion goal: 2007

- **One of the top 5 acquisition M&S projects for MSSC FY08 funding**

Next steps:

- **Monitor MSSC project if funded**

Objective 5: Shape the Workforce

5-1. Define required M&S competencies for the acquisition workforce

Co-Leads: DAU and OUSD(AT&L)/DS(SSE); **Support:** OUSD(P&R), OUSD(AT&L)/DDRE, OUSD(C)/PA&E, Components

Product: Identified lead FIPT; workforce qualification requirements; management process & structure

Completion goal: 2008

- **"Educating the M&S Workforce" project underway with Navy & MSSC funding**
- **FY08 funding increment being considered by MSSC**

Next steps: **No further activities needed now**

Objective 5: Shape the Workforce

5-2. Harvest lessons from commercial sector activities in the use of M&S to support product development

Lead: OUSD(AT&L)/DS(SSE); **Support:** OUSD(AT&L), Components

Products: Annual update to best practices in DAG and lessons from industry that should be considered by PMs in planning for M&S

Completion goal: Recurring; initial in 2007

- **SSE participating in conferences, workshops, and literature review involving commercial industry use of M&S, capturing relevant points**
- **Increasing industry adoption of "Simulation-Based Design (SBD)**

Next steps:

- **Collect and consolidate findings, feed into Action 5-3 BoK**

Objective 5: Shape the Workforce

5-3. Assemble and evolve the M&S Body of Knowledge (information set) relevant to acquisition

Lead: OUSD(AT&L); **Support:** OUSD(AT&L)/DS(SSE), Components

Product: Information base available to potential M&S users (e.g., PMs, CMs, OTAs); source material for education and training

Completion goal: Recurring; initial in 2006

- **Several BoKs have been discovered**
- **Knowledge is being developed (e.g., best practices)**

Next steps:

- **Synthesize a consolidated BoK, put into configuration management, make accessible (how much of this is accomplished by Education Project is TBD)**

Obj. 5: Shape the Workforce (cont.)

5-4. Educate and train the workforce to achieve required M&S competencies

5-4(a) Provide M&S knowledge via an expanded set of DAU courses, the Defense Acquisition Guide, and on-line CLMs

Lead: DAU; **Support:** OUSD(AT&L), OUSD(AT&L)/DS(SSE), Components

Product: Expanded set of DAU courses, improved M&S guidance in the Defense Acquisition Guide, on line Continuous Learning Modules; a better educated workforce

Completion goal: 2009

- **CLM M&S for SE with over 1,600 graduates**
- **CLM on M&S for T&E just released**
- **DAG will be enhanced as information defined**
- **No action on DAU courses thus far**

Next steps: Nothing further needed now; BoK is prerequisite

Obj. 5: Shape the Workforce (cont.)

5-4. Educate and train the workforce to achieve required M&S competencies

5-4(b) Provide M&S knowledge via conferences, workshops, and assist visits

Lead: OUSD(AT&L)/DS(SSE); **Support:** OUSD(AT&L), DAU, Components
Product: Annual outreach program; a better educated and trained workforce
Completion goal: Recurring; initial in 2006

- **FY07 Outreach Plan approved by AMSWG; includes M&S tutorial for AS staff, DMSC, NDIA and SISO presentations**
- **Add'l materials (e.g., best practices) in work**
- **Resource constrained**

Next steps:

- **Advertise and expand assist visits**
- **Hold workshops once recommended practices are in hand**

Obj. 5: Shape the Workforce (cont.)

5-5. Improve the knowledge and expertise available through the MSIAC to make it of greater utility to the acquisition community

Lead: OUSD(AT&L); **Support:** OUSD(AT&L)/DS(SSE), OUSD(P&R), OUSD(C)/PA&E, Components

Product: Plan of action with coordinated MSIAC CONOPS & staffing requirement; list of knowledge shortfalls that MSIAC will take on; success criteria & process to bring MSIAC up to criteria

Completion goal: 2008

- **Only preliminary conversations with MSIAC contractor thus far**

Next steps:

- **Develop a plan of action to improve the M&S Information Analysis Center's usefulness to the acquisition community**

Discussion

Developing An Integrated Process Methodology For Interim Software Releases

October 23, 2007

Authors

Tim Woods
Ph.D. Candidate

Jerrell Stracener, PhD
Founding Director
Systems Engineering Program

Agenda

- Background
- Introduction
- Complexity of Systems of Systems
- Software Complexity
- Software Release
- Integrated Process Methodology
- Future Work
- References

Background

SMU

- Currently PhD Systems Engineering (SE) Candidate At Southern Methodist University
  - Presentation Is Part Of Dissertation Research
- Worked 20+ Years As Systems Engineer
  - Supporting Aircraft Flight Control Systems Both Commercial And Military
  - SE Consultant/Tool Vendor
- Currently Perform Software Release Activities For Military Aircraft Systems

Introduction

SMU

- System of Systems (SoS)
  - Definition From INCOSE Handbook:
    - System of systems applies to a system-of-interest whose system elements are themselves systems; typically these entail large scale inter-disciplinary problems with multiple, heterogeneous, distributed systems.
- Definition Contains “Large Scale Inter-Disciplinary Problems” For A Reason
  - SoS Breeds Complexity, Increasing The Integration Required For Software, And Increasing The Complexity Of The Decision Process For When To Release Interim Software

Complexity Of SoS

- Working On Your Own Car – One Of America’s Past Times
  - Due To Complexity Of Cars Today – Almost A Thing Of The Past
  - Cars Today Contain Greater Complexity Than Previous Models
    - A Car May Contain 50 Microprocessors
  - Future Technologies Driving Additional Complexity
    - Drive By Wire

Complexity Of SoS (Continued)

- Aircraft Have Always Been Complex Systems
- Today, Aircraft Are Incorporating More And More Features
  - Increases Complexity And Integration Of Systems
- Previously, Flight Control Software Could Be Released Without System Integration Testing With Avionics Software
  - Today The Software Is So Tightly Integrated Providing Advanced Automodes, Even The Slightest Of Changes Requires System Integration Testing

Software Complexity

- Joint Strike Fighter (JSF) Software Growing
  - General Accounting Office (GAO) Reported To Congressional Committees
    - March 2006 – Program Would Develop 19 Million Lines Of Code (LOC)
    - March 2007 – Program Would Develop 22 Million LOC
  - In One Year, Estimate Increased By 3 Million LOC Or 16%
  - Just Think Of The Complexity Added In Those Previously Unaccounted For 3 Million LOC
  - Number Of Actual Software Releases Not Given
    - Software Delivered Over 5 Blocks
    - Assume Software Releases Number More Than The 5 Delivery Blocks

Software Complexity (Continued)

- One Word –
  - Windows 3.1
    - Approximately 3 Million LOC
  - Windows 95
    - Approximately 15 Million LOC
  - Windows Vista (Latest Operating System)
    - Approximately 50 Million LOC
  - As Everyone Knows, The More Code Added, The Less Complex Microsoft's Operating System Became – Right?
  - Multiple Releases For Each Operating System

Software Release

- Production Software Release
  - Definition As Used Here:
    - A Release To The End Customer That Is Validated And Verified And Meets All Requirements
    - End Customer Is Customer That Receives The Software After All Verification And Validation Activities Are Complete
  - Some May Call This Final Release
    - Requirements, Design, Verifications, Validations, And Testing All Complete
  - Sense Of Accomplishment

Software Release (Continued)

SMU

- Interim Software Release
  - Definition As Used Here:
    - A Release That Is Not Fully Verified Or Validated To All The Requirements
  - Software Release Occurring Before Production Release
  - Often Times Requirements, Design, Verifications, Validations, And/Or Testing Is Not Complete
    - Interim Releases Used To Complete Design, Verifications, etc.

Software Release (Continued)

- Imagine A SoS Program Today
  - Difficult, If Not Impossible, To Proceed With Only A Production Software Release
  - The Complexity And Integrated Nature Of SoS Almost Requires Interim Releases
- With That Said
  - Take Today's Integrated SoS Environment
  - Add In Program Schedule Pressures
  - All Equals Complex Decisionology Regarding When To Release Interim Software
- A Process Methodology For Assisting In Interim Software Release Decision Making

Integrated Process Methodology

SMU

- An Integrated Process Methodology Being Developed For Assisting Decision Making Regarding When To Release Interim Software
- Proposed Integrated Process Methodology Considers:
  - Incomplete State Of Program That May Exist For An Interim Release
  - Interfaces, Problem Reports, Resources, Requirements, Software Criticality, Schedules, etc.
- Assist In Determining The Optimal Time To Produce An Interim Software Release Given Multiple Release Paths And Multiple Integrated Software Products, While Considering The Factors Mentioned Above

Integrated Process Methodology (Cont)

- Proposed Integrated Process Methodology Not Meant To Replace Software Planning
  - Aid In The Software Release Decision Making Process
  - Software Plan Used As An Input To The Integrated Process Methodology Decision Matrix
- Nor Is The Process Methodology Meant To Solve The Question Of When To Release Software
  - Allows The Decision Makers To Make Better Decisions Regarding When To Release Software

Integrated Process Methodology (Cont)

- Goals Of Integrated Process Methodology
  - Aid In Decision Making Process By Provide An Analytical Methodology
  - Replace Non-productive Decision Methodologies Currently In Use
    - For Instance – BOGSAT (Bunch Of Guys Sitting Around Table), Squeaky Wheel, etc.
  - Replace Multiple Smaller Software Releases With Fewer, More Integrated Releases

Integrated Process Methodology (Cont)

SMU

- Cost And Schedule Normally Constrain The Number Of Software Releases For A Particular Program
  - Normally, Releasing Software Incurs Both A Schedule And Monetary Cost
    - Takes A Finite Amount Of Time To Make, Build, Release, Document, And Minimally Test Release
    - During The Release, Resources Used (People, Computers, Labs, Etc.) Not Available To Perform Other Tasks
  - Consequently, Fewer Software Releases Equates To Less Cost To Program

Future Work

- Define Generic Interim Software Release Process
  - Accounting For A Program’s Unfinished Nature During Interim Software Releases
- Develop And Verify The Integrated Process Methodology

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<u>Developing An Integrated Process Methodology For Interim Software Releases</u>

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Abstract

This paper covers factors that make production software releases successful – design complete, requirements complete, testing complete, customer expectations set, etc., and how a production software release process may not be fitting for an interim software release due to the state of the program during an interim release – one or all of the production release success factors possibly being incomplete, open system problem reports, interactions with other systems – hardware, communications and software interfaces, schedule interactions, resource constraints, etc. A discussion will follow on the need for an integrated process methodology that factors the incomplete nature of a program during an interim software release into the release decision methodology. The goals for the integrated process methodology will be discussed along with the next steps in developing the integrated process methodology for interim software releases.

Introduction

Today's complex systems are becoming more and more integrated, as evidence by the growing field of Systems of Systems (SoS). Consequently, software is being integrated with other processors within its own system and across interfaces within the <u>total</u> system itself, increasing the complexity and integration required for software releases.

SoS Adds Complexity

SoS, as the name implies, is a system comprised of other systems. Creating a system composed of other systems adds additional complexity and integration challenges. For instance, cars today may have 50 microprocessors controlling <u>everything</u> from the engine to the air bag [1]. Every microprocessor runs its own software and probably interfaces with additional microprocessors, driving additional complexity and integration pains. The Drive By Wire [2] technology for future cars, will only increase the complexity and integration challenges. In the past cars could be serviced by mechanically inclined

individuals who did not mind getting their hands dirty. Today, one practically needs a degree in software engineering to service cars.

Aircraft have always been complex, integrated systems, but today, as more systems integrate with each other, the aircraft is becoming more complex and tightly integrated. Not long ago, the flight control software (commands surfaces to keep the aircraft flying) could be released with minimal to no integration testing with avionic software (controls the mission). Today the flight control and avionic software are tightly integrated providing advanced functions. This integration demands that even the smallest of software changes drives system and integrated testing to insure the software changes did not detrimentally affect the aircraft in some unforeseen manner.

The complexity and integration requirements of a SoS affects the system's software and its safety implications. As Leveson [3] points out:

> Today we are building systems – and using computers to control them – that have the potential for large-scale destruction of life and the environment: Even a single accident may be disastrous.

Today's added complexity, additional requirements, and criticality of software, means the decision of when to release software is becoming as complex as the software itself. This paper will explore a software release methodology that considers the complexity, integrational aspects, and criticality of today's software.

Software Complexity

Software is complex and becoming more complex daily. As an example, take the Joint Strike Fighter (JSF) program. In March of 2006 in a report from the General Accounting Office (GAO) to Congressional Committees, it was reported that the JSF program would develop 19 million lines of code [4]. In March 2007, the GAO reported the program would develop 22 million lines of code [5]. In one year the estimate increased by 3 million lines of code or 16%. Just think of the complexity added in those previously unaccounted for 3 million lines of code. The JSF software was to be delivered in 5 different blocks, but the number of actual software releases was not given. It can be assumed that the software releases will number more than the delivery blocks.

Looking at the number of lines of code can give an idea of software complexity, the more lines of code, the more complex the software. Looking at Microsoft's LOC count shows an interesting trend [6]:

> Real systems show no signs of becoming less complex. In fact, they are becoming more complex faster and faster. Microsoft Windows is a poster child for this trend to complexity. Windows 3.1, released in 1992, had 3 million lines of code; Windows 95 has 15 million and Windows 98 has 18

> million. The original Windows NT (also 1992) had 4 million lines of code; NT 4.0 (1996) has 16.5 million. In 1998, Windows NT 5.0 was estimated to have 20 million lines of code; by the time it was renamed Windows 2000 (in 1999) it had between 35 million and 60 million lines of code, depending on who you believe.

Windows Vista, Microsoft's latest operating system, reportedly contains 50 million lines of code [7]. The number of software releases for a product with 50 million lines of code has to be large. Imagine performing only one software release for a product with 50 million lines of code.

Software Releases

Given today's integrated environment, releasing production software is an accomplishment in itself. With a production release, the design is complete, testing is complete, requirements are verified, outstanding problems are mitigated, contractual obligations have been met, the schedule no longer is a plan, it is the actuals for the program, and significant management oversight – sometimes known as help – is provided, making the path for a production release familiar and the process well known. Accompanying a production release is a sense of accomplishment for a job well done and possibly the end of the program.

With all that said, defining production release, as used in this paper, is required. A literature search will discover many terms and definitions related to software releases [8, 9, 10, 11]. For the purpose of this paper, production software release will be defined as a release to the end customer that is validated and verified to meet all the requirements. Along the same lines, an interim software release is a release that is not fully verified or validated to all the requirements. Customer, as used here, is defined as a user of the software. A customer could be internal or external to the company. An end customer is the customer that receives the software after all verification and validation activities are complete.

In today's integrated, SoS environment, it would be difficult, if not impossible, to proceed through a production software program of any size with only a production software release. The complexity and integrated nature of SoS almost requires interim releases before the production release.

If the path to production release is well known and familiar, does it necessarily follow that the production software release path/process is adequate for interim software releases? Production software releases benefit from the completeness of the design, testing, requirements and problem mitigations, interim releases usually do not have those luxuries. An interim release usually contains partial functionality and may even occur before the design is complete and may be used to complete requirement verification meaning requirements may not be verified. Because design may be on-going, testing may not be complete, requirements may still require verification, and outstanding high

severity problems may not be mitigated, a production release process may not suffice for an interim release. Today's integrated SoS environment along with program schedule pressures add to the complexities of interim release decision making.

Integrated Process Methodology

An integrated process methodology is being developed for assisting in the decision making regarding when to release interim software. The integrated process methodology will consider the incomplete state of the program that exists for an interim release and additional factors that could affect a release such as interfaces, problem reports, resources, requirements, software criticality, and schedules. The integrated process methodology will assist system development programs in determining the optimal time to produce an interim software release that supports its intended purpose, given multiple release paths and multiple integrated software products, while considering the factors mentioned above.

The proposed integrated process methodology is not meant to replace software planning, but aid in the software release decision process. The software plan would be used as an input to the integrated process methodology decision matrix to assist in determining the optimal release path for a specific interim software release. Nor is the process methodology meant to solve the question of when to release the software, but to allow the decision makers to make better decisions regarding when to release software. The methodology's benefits will be especially useful as the decision of when to release software becomes more difficult. Keeney's [9] take on difficult decisions and analysis:

> More Difficult decision problems are naturally more difficult to analyze. This is true regardless of the degree to which formal analysis (i.e., use of models as a decision aid) or intuitive appraisal (i.e., in one's head) is used. However, as complexity increases, the efficacy of the intuitive appraisal decreases more rapidly than formal analysis.

Software release decisions are difficult by themselves, but when combined with the problems SoS introduces, there may be too much information required to properly process the decision. The decision maker may then use simplified mental strategies, without using decision analysis methods [10]. The integrated process methodology would be used to analyzed the information provided and aide in the decision making process, with the goal of replacing non-productive decision methodologies currently in use, like BOGSAT (Bunch Of Guys Sitting Around Table). Ideally, the integrated process methodology will provide an analytical methodology to aid in the software release decision process with the hopes of replacing multiple smaller software releases with fewer, more integrated releases.

The goal of the process methodology is to reduce software releases. That's a good thing, right? If it is just software, can't it be released anytime? While it is true that software can be released anytime, cost and schedule normally constrain the number of software releases for a particular program. Normally, releasing software incurs both a schedule and monetary cost. It takes a finite amount of time to make, build, release, document, and minimally test the release. During the release, the resources used (people, computers, labs, etc.) are not available to perform other tasks (incurring schedule costs) and must be paid for their time (incurring monetary cost). Consequently, the fewer software releases needed, the less the cost to the program.

Future work includes defining a generic interim software release process, developing the integrated process methodology, verifying the process' decision matrix, verifying the integrated process methodology, and optimizing the process methodology.

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[1] Karim Nice (2001, April 11) How Car Computers Work, Retrieved April 09, 2007 from http://auto.howstuffworks.com/car-computer.htm .

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[5] Joint Strike Fighter: Progress Made and Challenges Remain, GAO-07-360, March 15, 2007.

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Author Biographies:

Tim Woods is currently a PhD in Applied Science candidate in the Southern Methodist University (SMU) Systems Engineering Program. He is currently leading a project to assist in developing a PhD in Systems Engineering program for the SMU Systems Engineering Program, while finishing the necessary course work for his PhD.

Currently he is working in the defense industry as a Systems Engineer and has supported several major fighter aircraft programs and worked commercial aircraft programs. Prior to re-joining the defense industry, Tim spent three years working for a systems engineering software tool company and performed systems engineering consulting for customers across the commercial and defense industries. Tim is a current member of INCOSE.

Mr. Woods earned MS degrees in Engineering Management and Systems Engineering from SMU and a BS in Electrical Engineering Michigan Technological University.

Jerrell T. Stracener is the founding Director of the SMU Systems Engineering Program. He also teaches graduate-level courses in Probability & Statistics, Reliability Engineering, Statistical Quality Control & Systems Analysis and conducts systems engineering research, consulting and training.

Prior to joining SMU full-time in January 2000, he was employed with Vought/Northrop Grumman for 31 years. Jerrell was a reliability engineer and ILS program manager on many advanced aircraft programs including the Lockheed Martin Joint Strike Fighter and the B-2.

Jerrell has actively promoted systems engineering & analysis, and reliability, maintainability, supportability & logistics through his leadership as founding member & chairman of the SAE RMSL Division and through participation INCOSE, AIAA & SOLE.

Dr. Stracener earned PhD & MS degrees in Statistics from SMU and a BS in Math from Arlington State College (now UTA).

Tools and Resources to Enable Systems Engineering Improvement

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Deputy National Competency Lead for ISR/IO 5.6

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Technical Software Services, Inc.
Director, Implementation and Support
SEI Authorized Instructor

10th Annual Systems Engineering Conference
October 23, 2007

N65236-ENGOPS-BRIEF-0044-1.3

Presentation Outline

- **Vision and Strategy**
  - Elements of Implementation
- **Process Asset Library**
- **Tools**
  - ePlan Builder and eWBS
  - Organizational Measurement Repository
- **Training**
  - Training Architecture
  - Courses
- **Results**
- **Going Forward**

Process Improvement and Systems Engineering Strategy - 2003

- **Vision**
  - Develop and maintain a World Class Systems Engineering Organization
- **Approach**
  - Achieve Command-wide operational consistency
  - Based on ISO 15288 – systems engineering
  - Based on ISO 12207 – software engineering
  - Measure using best practices of CMMI®
- **Goals**
  - CMMI Maturity Level 2 by April, 2005
  - CMMI Maturity Level 3 by April, 2007

Both Goals attained on schedule

1st SPAWAR Systems Center to Achieve ML2 and ML3

New Goal: Maturity Level 4 by 2010

Which one is World Class?

Systems Center Charleston

When you want it done right,
Who do you want working on it ?

Cutting corners, undisciplined, untrained

Rigorous processes, Skilled resources

Permission to use Redneck Mechanic photo received from Dave Lilligren, 3/9/2007
Permission to use NASCAR Technical Institute photo received from Popular Mechanics, 3/16/2007

SEI Partner
TECHSOFT
Technical Software Services, Inc.

Critical Success Factors

CRITICAL SUCCESS FACTORS FOR SE REVITALIZATION	
Command-wide Policy (Create vision that is urgent)	Assign Responsibilities (Strong Change Agents are essential)
Strategy and Plan (Include knowledge of why change is necessary and benefits)	Provide Training
Senior Management Support	Build Central Repository
Provide Resources and Funding (New Organizational Structure Usually Needed)	Measure and Communicate Progress

SSC-C SE Revitalization Plan Aligned with DoD SE Revitalization

Systems Center Charleston

Elements of SSC-C SE Revitalization

Policy / Guidance

- SSC-C SE Instruction
- SSC-C SE Process Manual
- SSC-C SW-Dev Process Manual
- SSC-C SW-Maint Process Manual
- EPO Website
- ePlan Builder

Training / Education

- Intro to PI WBT
- SE 101 WBT
- SE Fundamentals
- SE for Managers
- Project & Process Workshop
- Intro to Software Engr.
- Architecture Dev. WBT
- Certification/Degrees

Assessment & Support

- CMMI® Level 2
- CMMI® Level 3
- CMMI® Level 4/5
- Project Reviews
- Balanced Scorecard
- Lean Six Sigma
- Integrated Product Teams
- IT Tools

Underway

Completed/Ongoing

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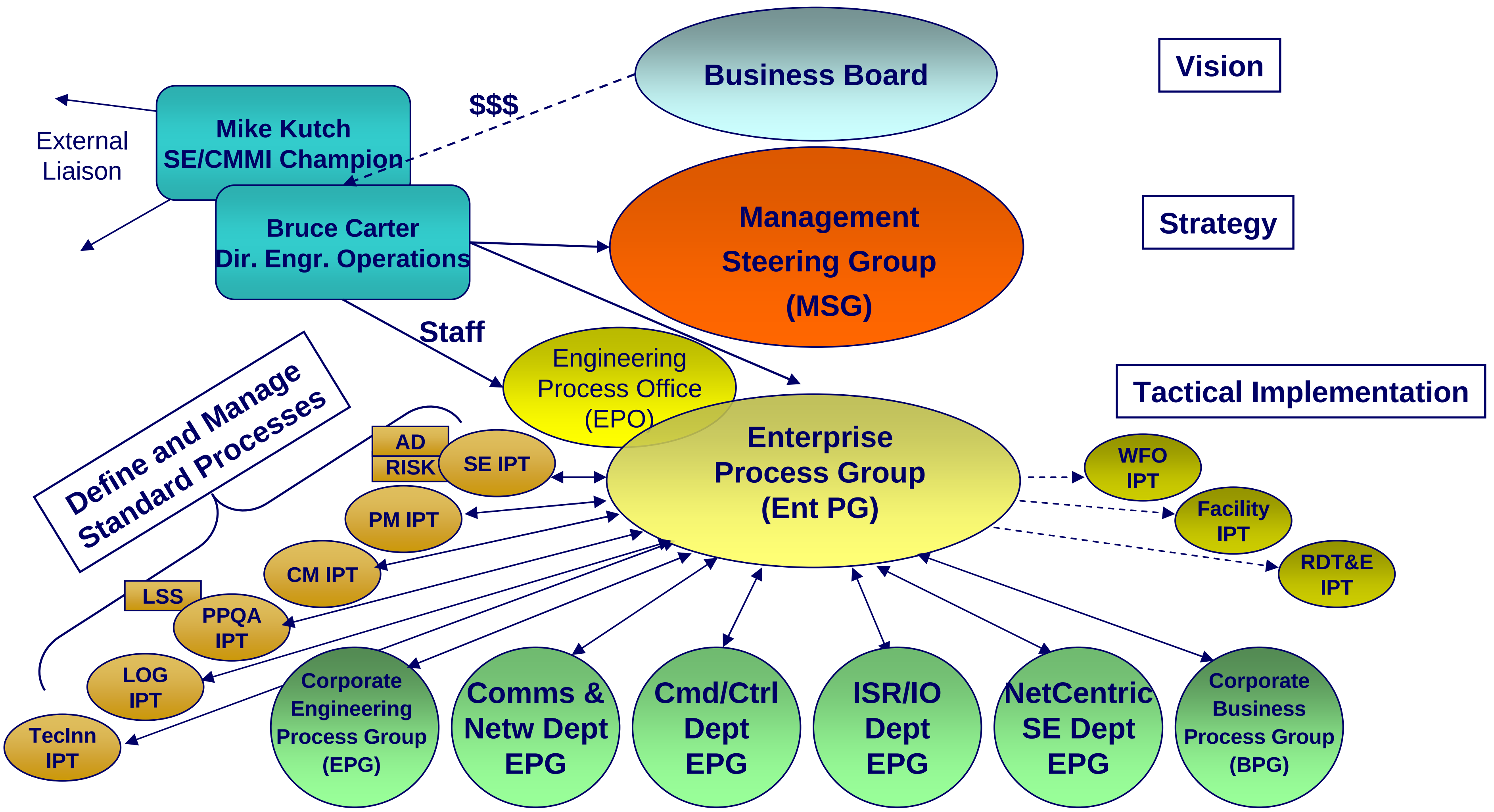
Process Improvement Infrastructure: Organization

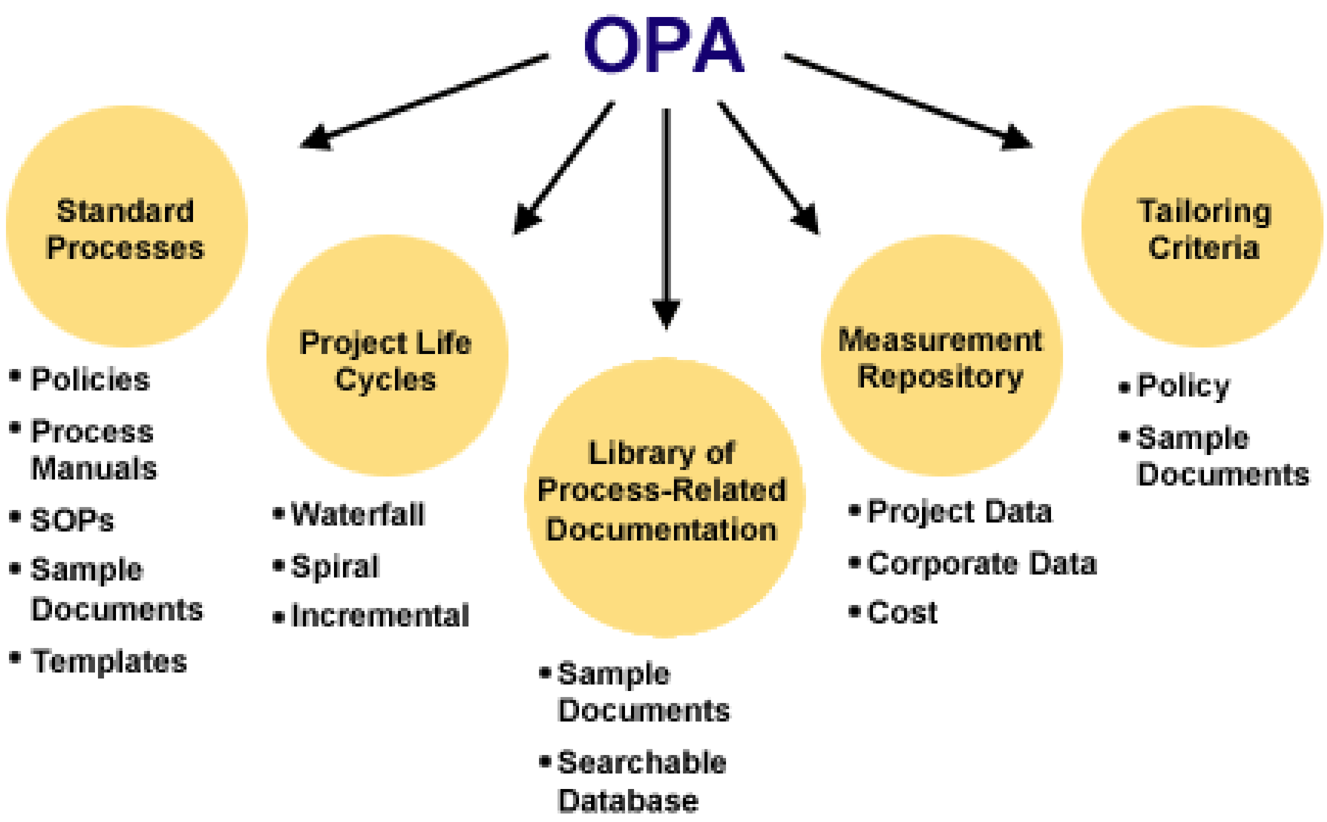


Engineering Process Office (EPO)

Engineering Process Office (EPO)

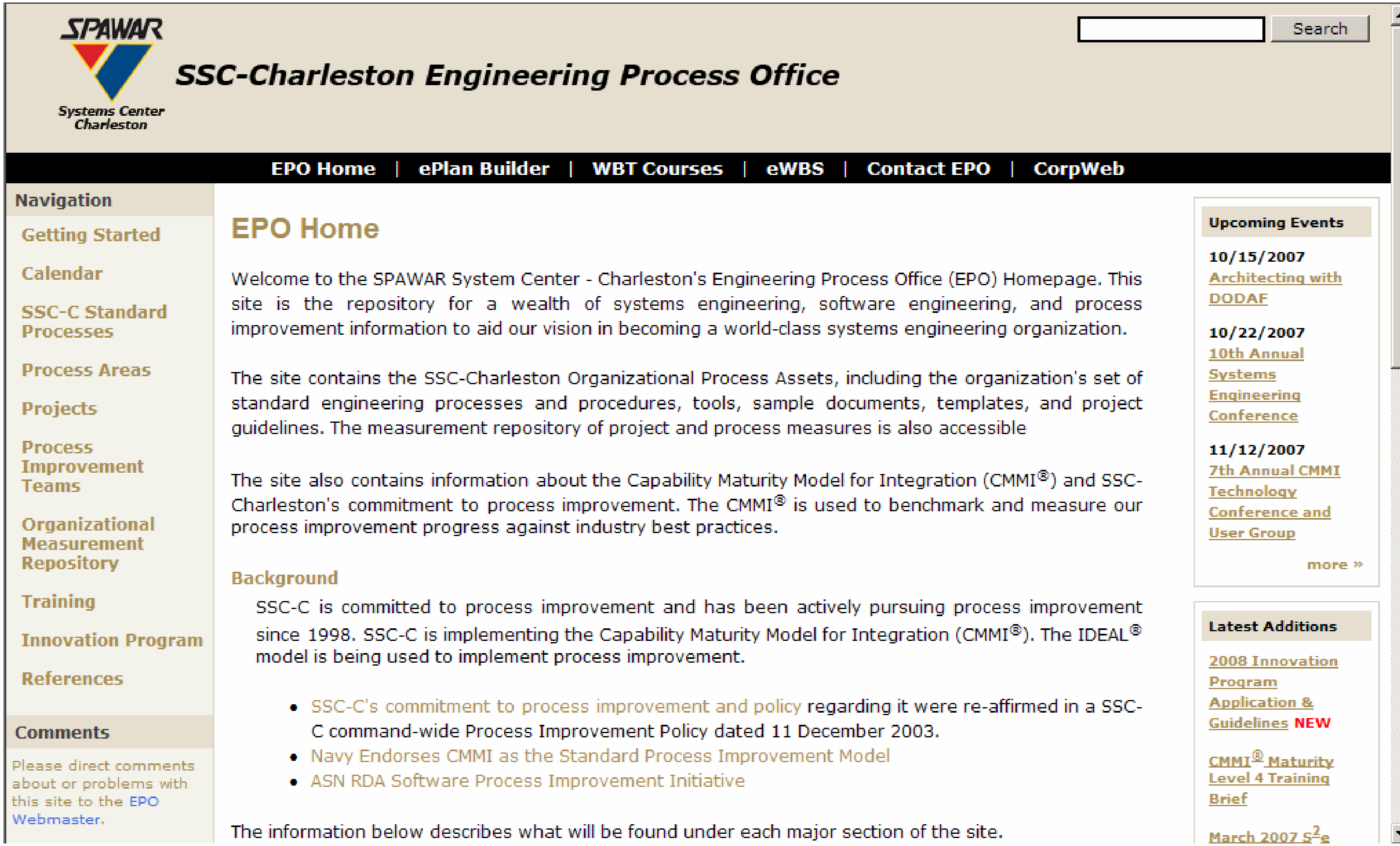
- **Supports the Director of Engineering Operations**
- **Developed Policies**
  - Policy for each CMMI Level 2, 3, 4, & 5 Process Area
- **Developed Standard Process Manuals**
  - Top Level
    - Systems Engineering
    - Software Development
    - Software Maintenance
  - Supporting Processes
    - Process Manual for each CMMI Level 2, 3, 4, & 5 Process Areas
    - Additional process documentation as needed – Reviews, Tailoring, etc
- **Develop plan templates**
- **Coach and mentor selected projects**
- **Build tools**
- **Develop and deliver training**
- **Perform interim assessments**

Recognized early need for central repository for Organizational Process Assets



EPO website provides access to all of SSC-C's organizational process assets

Approximately 100 pages of content; over 1000 documents available



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Process Area Pages

SSC-Charleston Engineering Process Office

Search

EPO Home | ePlan Builder | WBT Courses | eWBS | Contact EPO | CorpWeb

Navigation

- Getting Started
- Calendar
- SSC-C Standard Processes
- Process Areas
  - Project Planning (PP)
  - Project Monitoring & Control (PMC)
  - Configuration Management (CM)
  - Process and Product Quality Assurance (PPQA)
  - Requirements Management (REQM)
  - Measurement & Analysis (MA)
  - Supplier Agreement Management (SAM)
  - Requirements Development (RD)
  - Technical Solution (TS)

Project Monitoring & Control (PMC)

Project Monitoring and Control (PMC) is a Level 2 (Managed) Process Area. The purpose of PMC is to provide an understanding of the project's progress so that appropriate corrective actions can be taken when the project's performance deviates significantly from the plan.

Policy Document

- SSC-C Project Monitoring and Control Policy

Process Manual

- SSC-C Project Monitoring and Control Process Manual

SOPs

- In Process Review SOP
- Project Management Review SOP
- Meeting SOP

Sample Documents

- IBFTC PMC Plan
- CICS Project Management Plan (PMP)
- Towed Array Earned Value Plan

Templates

- PMP Plan

Related Process Areas

- Project Planning (PP)
- Measurement & Analysis (MA)

Each CMMI process area has a standard page with links to policy, process manual, SOPs, Sample/Project documents, and other resources

Projects Section

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Search

SSC-Charleston Engineering Process Office

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Comments

Standard CMMI Appraisal Method for Process Improvement (SCAMPI) Appraised Projects

SSC-C SCAMPI Appraisal Summary

SPAWAR Systems Center - Charleston - Maturity Level 3

- Sponsor: Mike Kutch
- Projects Appraised: AP, CICS, IBFTC, JTWS, SCN, VIDS, NAVMACS II, SSES, Towed Array
- Appraised 27 April 2007

Integrated Battle Force Training Center (IBFTC) - **Maturity Level 3**

- Program Manager: Lexine Langley
- Code 856
- Appraised 26 January 2007

Visual Information Display System (VIDS) - **Maturity Level 3**

- Program Manager: Steve Whitbeck
- Code 663
- Appraised 15 December 2006

Naval Modular Automated Communications System II (NAVMACS II) - **Maturity Level 3**

- Program Manager: John Dyar
- Code 523
- Appraised 15 December 2006

Shipbuilding and Conversion, Navy (SCN) - **Maturity Level 3**

Each appraised project has a page and is expected to share good examples of plans and documents

Tools

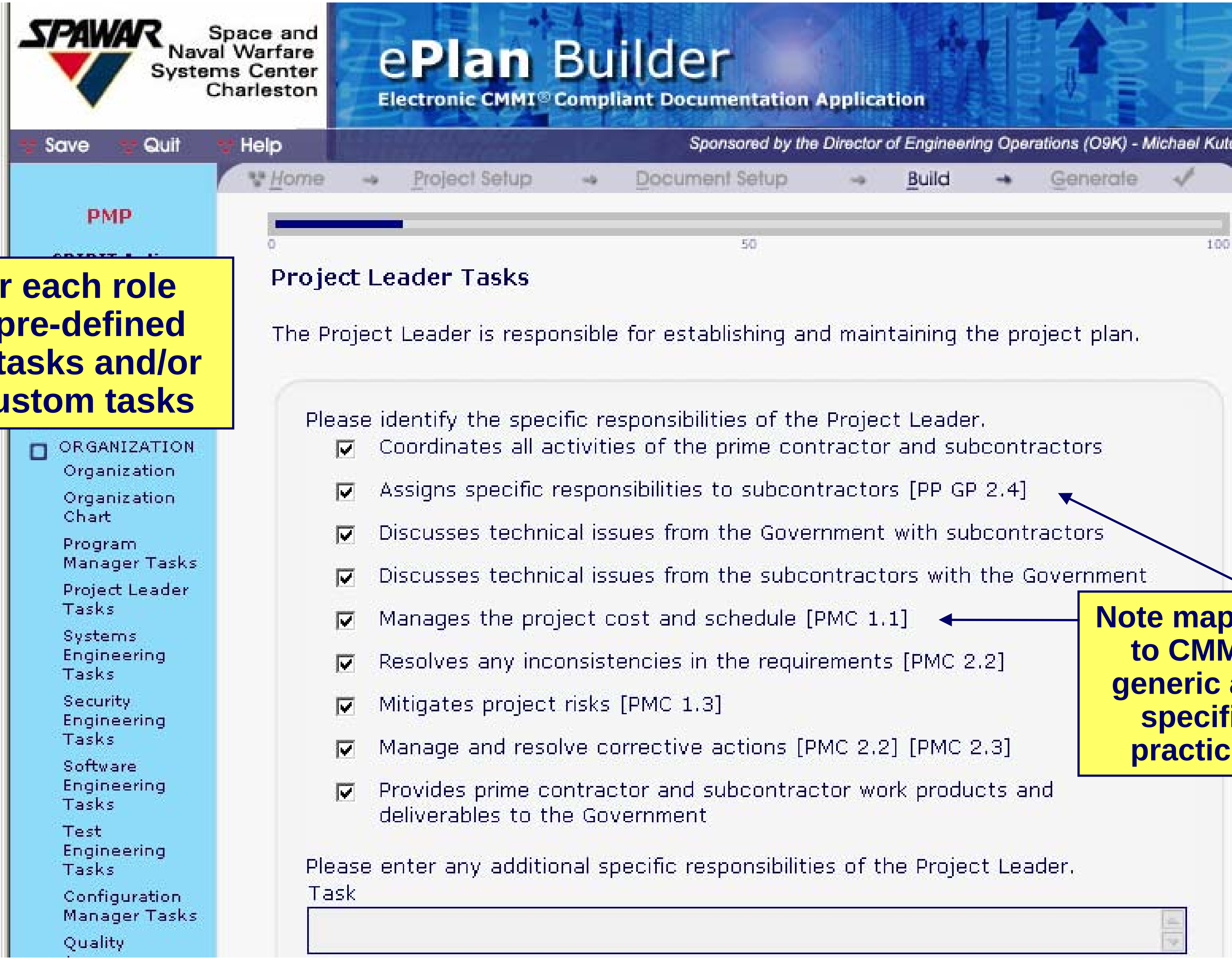
- ePlan Builder
- Organizational Measurement Repository
- Appraisal Wizard

ePlan Builder Tool

ePlan Builder tool

- An interactive, web-based application that leads the user through a structured interview process (like TurboTax®) to generate a CMMI®-compliant plan
- Includes standard, consistent text
- Generates an initial project-specific document
  - Project Management Plan (with Work Breakdown Structure)
  - Configuration Management Plan
  - Process and Product Quality Assurance Plan
  - Requirements Management Plan
  - Measurement and Analysis Plan
  - Supplier Agreement Management Plan (by end of 2007)
  - Systems Engineering Plan (DoD SEP Format)

EPB – Select Tasks for each Role



Tailor each role from pre-defined list of tasks and/or add custom tasks

Note mapping to CMMI® generic and specific practices

Approved for public release; distribution is unlimited (3 OCT 2007)

Work Breakdown Structure (WBS) in a Project Management Plan

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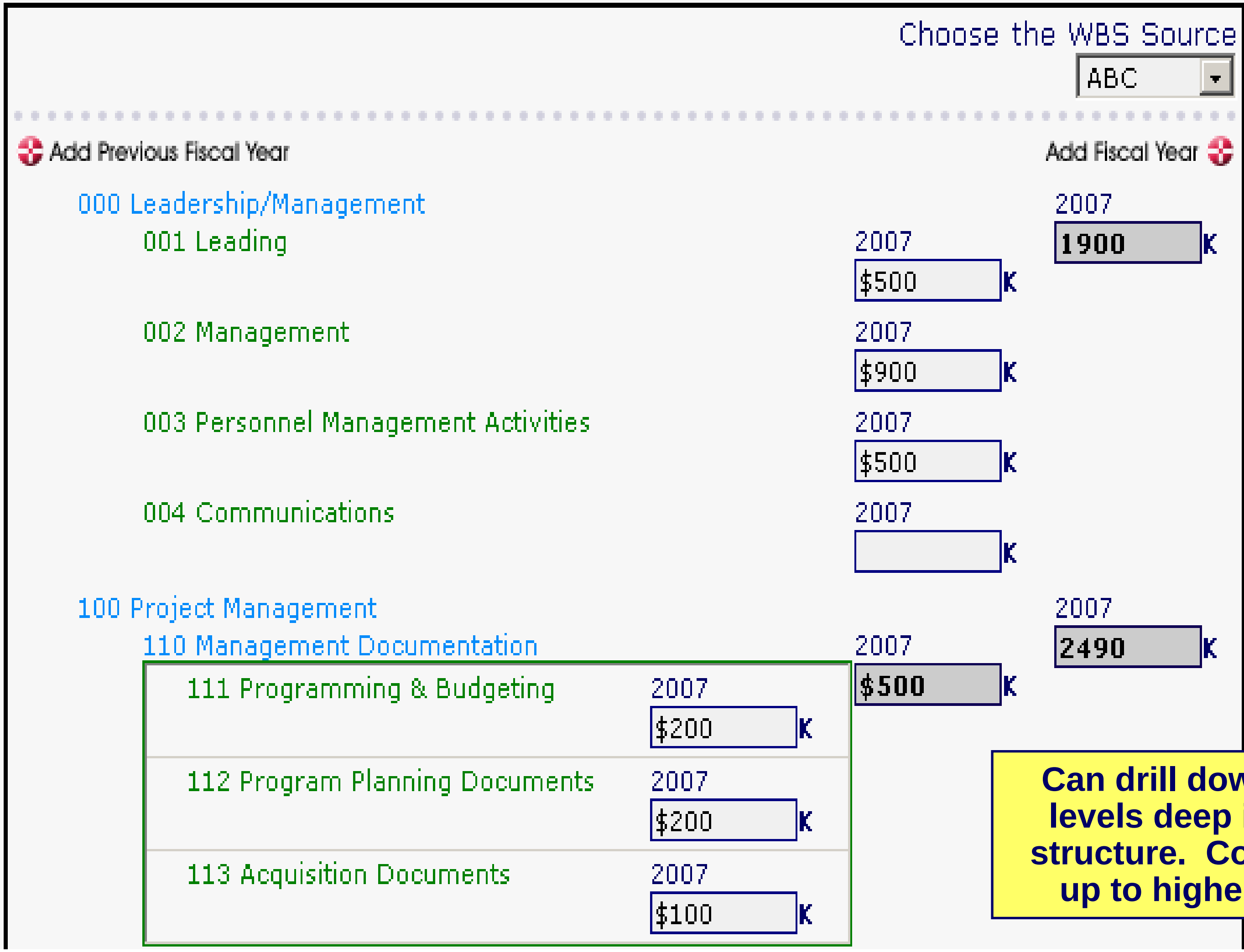

Cost estimates entered using the SPAWAR global WBS or the SSC-C Activity Based Costing WBS

ePB accommodates multi-year projects

Can drill down three levels deep in WBS structure. Costs sum up to higher level.

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Risk Identification in PMP

Risks

This page allows you to enter a list of known or expected risks. The severity of the risks and the mitigation approach for each should be identified. Please use the table below to identify the major risks associated with the project.

Click for more information about risks

Risk Category	Impact/Concern	Level	Mitigation Approach
Schedule	Products are required by the customer by 10/1/06	High	Be prepared to provide draft materials if development of
Quality	Will products be ready for 10/15/06 in a condition	Medium	Provide technical data to contractor in accordance with schedule with
Technical	Ability to get teh technical ata from the	High	Interact directly with the satellite manufacturer to obtain the technical

Add More Items

PMP may also reference a more comprehensive Risk Management Plan

Measurement & Analysis Plan

Cost, Schedule, and Process Performance are standard categories of measures

Collection, Storage, and Analysis is defined for each Project measure

Cost is a measure within the Financial Performance category that measures the cost for activities, events, and products. The measure provides an easy-to understand view of the budget. Comparison of planned and actual cost data provides insight into significant and repetitive cost changes at the activity level.

While more detailed cost information provides more insight into the project's total cost, until the project personnel have achieved a certain level of proficiency in estimating costs, it is recommended that the cost data should be captured at a level commensurate with this level of experience.

Collection and Storage

Identify the level of detail for capturing cost data

Project Level

Please select how the Project Leader will report contract costs from the list below. If the Project Leader is not responsible for managing contracts, select "Project".

Project

Identify who will provide the actual cost data:

Project Leader

Identify the tool to be used to collect cost data:

BSA and PMACS

Identify how often the actual cost data will be collected:

Monthly

Analysis Procedures

Identify how often the cost data will be analyzed:

Monthly

Identify the cost alert threshold:

95%

Systems Center Charleston

Systems Engineering Plan (SEP)

SEP format follows the DoD SEP Preparation Guide

SEP

NAS Pensacola OSP Survey

- PROJECT SETUP
- DOCUMENT SETUP
- PROGRAM
- INTRODUCTION
- ACQUISITION HISTORY
  - Previous Life-Cycle Phases
  - Next Life-Cycle Phase
- SYSTEM CAPABILITIES
- SE ORGANIZATIONAL INTEGRATION
- SYSTEM ENGINEERING PROCESS
- INTEGRATION
- INTEGRATED MASTER PLAN

0 50 100

Next Life-Cycle Phase

The SEP requires that the program's acquisition history and life-cycle phase be discussed, describing the top-level, technical process used in each life-cycle phase. This Next Life-Cycle Phase section should give an overview of the next planned life-cycle phase as well as summarize the process activities that are expected to be finished during the next life-cycle phase.

Please enter text discussing the Next Life-Cycle Phase of the program.

This description should give an overview of the planned SE process and should have more detail than the historical life-cycle processes completed. It should include how the technical process will be integrated into the life-cycle model and summarize the process activities that are expected to be finished during the next life-cycle phase.

Life-Cycle Phases (in hierarchical order):

1. Concept Refinement
2. Technology Development
3. System Development and Demonstration
4. Production and Deployment
5. Operations and Support

Show Hidden Text

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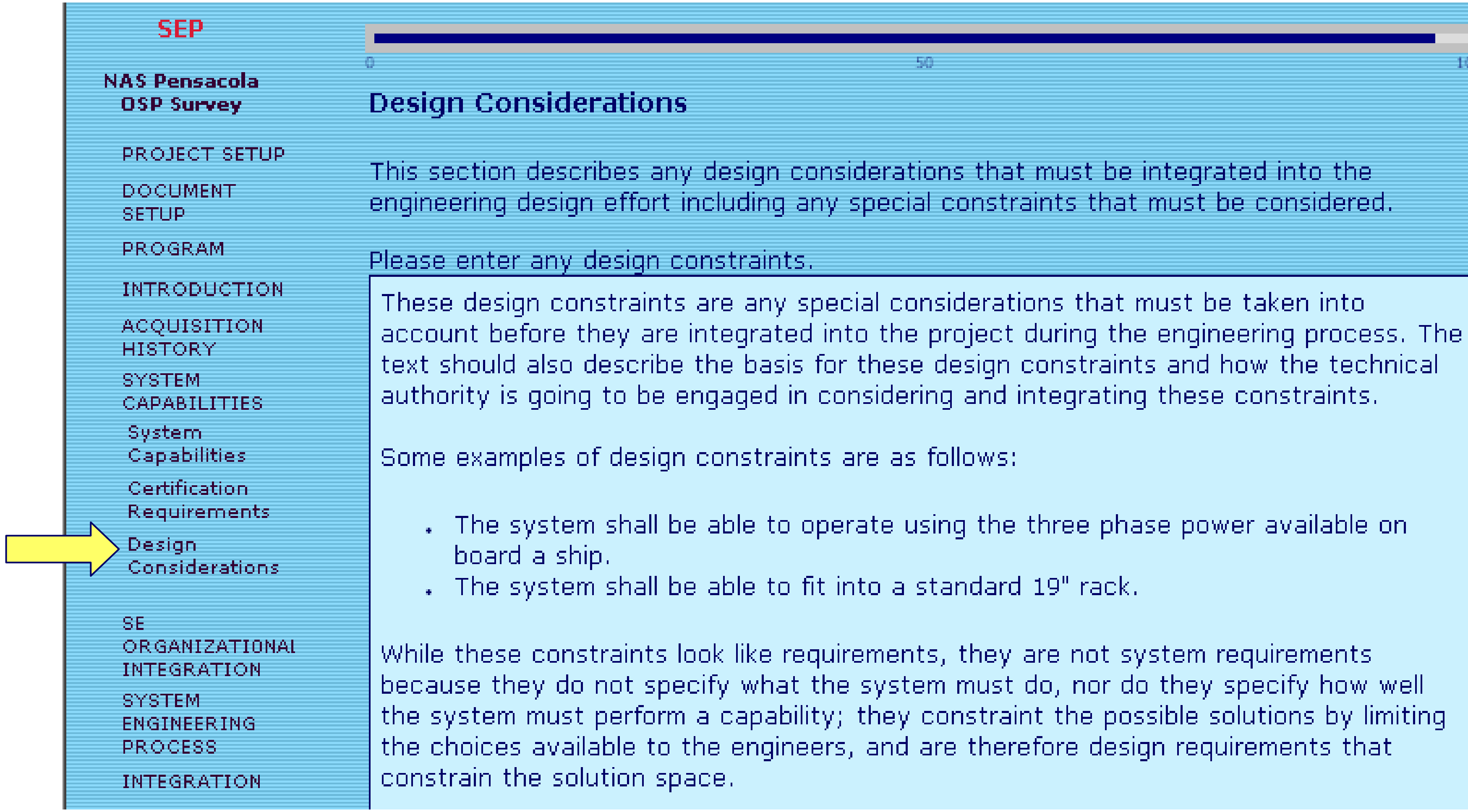
Systems Engineering Plan (SEP)

Systems Center Charleston



The nature of the SEP requires more open input text fields, but EPB helps by providing elaborations and examples for the user

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SEP – Planned Trade Studies

SEP

NAS Pensacola OSP Survey

- PROJECT SETUP
- DOCUMENT SETUP
- PROGRAM
- INTRODUCTION
- ACQUISITION HISTORY
- SYSTEM CAPABILITIES
- SE ORGANIZATIONAL INTEGRATION
- SYSTEM ENGINEERING PROCESS
  - Planning
  - Process Improvement
  - Modeling and Simulation
  - Resources
  - Trade Studies
- INTEGRATION
- INTEGRATED

0 50 100

Trade Studies

This section should include a brief description of the process used to determine trade-offs between various attributes of the program (e.g., between requirements and design). Information about how trade studies are addressed within the organization will be automatically embedded into the document. To view the embedded information about how trade studies will be addressed, click the "Click to view the embedded trade studies text" link below.

Click to view the embedded trade studies text.

Trade studies will be addressed in accordance with the *SSC-C Technical Solutions Process Manual* and *SSC-C Decision Analysis and Resolution Process Manual* where the development of alternate solutions, selection criteria and trade processes are discussed.

The actual trade studies to be performed on the program will be captured and listed in the control below.

Please enter the trade studies that will be conducted on this program.

Trade Study

Research on OSP topologies

Trade Study

Research on different conduit installation

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ePB Output
SEP Table of Contents

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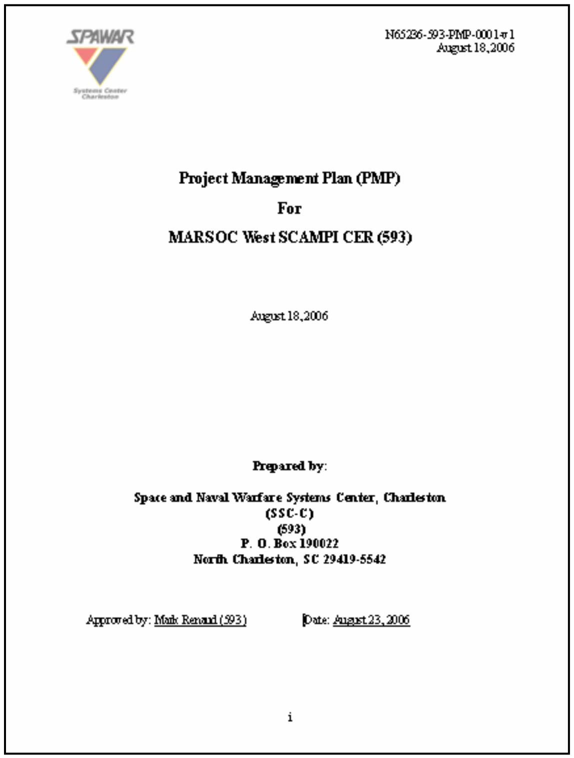
SPAWAR

Systems Center Charleston

N65236-593-PMP-0001 v1
August 18, 2006

Project Management Plan (PMP)

For

MARSOC West SCAMPI CER (593)

August 18, 2006

Prepared by:

Space and Naval Warfare Systems Center, Charleston
(SSC-C)
(593)
P. O. Box 190022
North Charleston, SC 29419-5542

Approved by: Mark Renaud (593) Date: August 23, 2006

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Appendix – CMMI® Compliance Matrix

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N65236-593-PMP-0001-v1
August 18, 2006

PROJECT PLANNING

CMMI®-SE/SW Goal/Practice Number	CMMI®-SE/SW Level 2 Process Area Project Planning (PP)	SSC-C PP Process Manual Paragraph	593 PMP Paragraph
1	Establish Estimates. Estimates of project planning parameters are established and maintained.	3.2	1.2.1
PP 1.1	Estimate the Scope of the Project. Establish and maintain a top-level work breakdown structure (WBS) to estimate the scope of the project.	3.2	1.2.1 3 Appendix A
PP 1.2	Establish Estimates of Project Attributes. Establish and document estimates of the attributes of the work products and tasks.	3.2	1.2.1 1.3
PP 1.3	Define Project Life Cycle. Define the project life cycle phases upon which to scope the planning effort.	3.2	1 1.2.1
PP 1.4	Determine estimates of Effort and Cost. Estimate the project effort and cost for the attributes of the work products and tasks based on estimation rationale.	3.2	1.3 1.2.1 Appendix A
PP 2	Develop a Project Plan. A project plan is established and maintained as the basis for managing the project.	3.3	1 1.2.1

Compliance matrix cross references CMMI® practices with associated SSC-C Process Manual and Project-specific plan

(No matrix for SEP)

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Organizational Measurement Repository (OMR)

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- Organizational database for collecting standard project measures and providing analysis
- Currently, the OMR accepts the following standard project measures

Category	Core Measure
Schedule Performance	• Estimated vs. Actual Milestone dates • Estimated vs. Actual Monthly Task completions
Cost Performance	• Estimated vs. Actual Milestone costs • Estimated vs. Actual Monthly costs
Process Performance	• Total # of noncompliance issues

OMR Structure

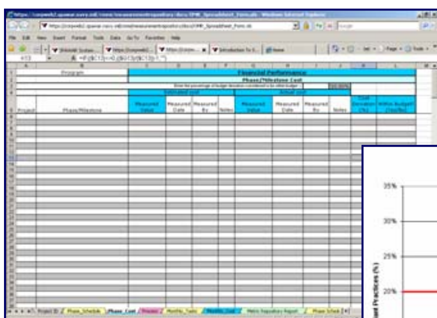
OMR Datastore

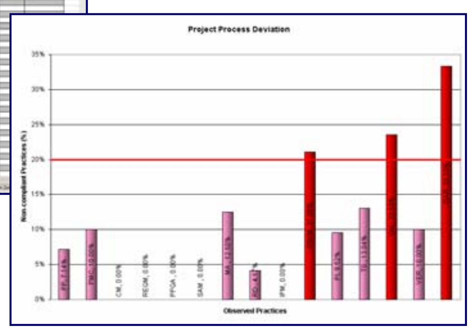
OMR Client Application

Metrics Inputs

Analysis

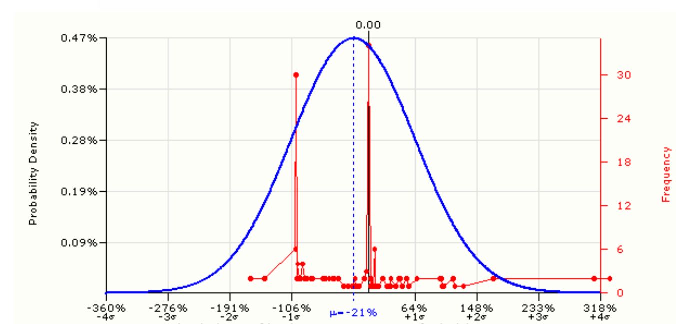
Project Performance





Organizational Performance & Analysis

Population Size: 172
Mean: -21.22%
Median: -6.22%
Mode: 0.00%
Min: -163.12%
Max: 330.77%
Variance: 71.85%
Standard Deviation: 84.76%
Probability of X < Min: 4.75%
Probability of X > Max: 0.00%
Probability of Min < X < Max: 95.25%



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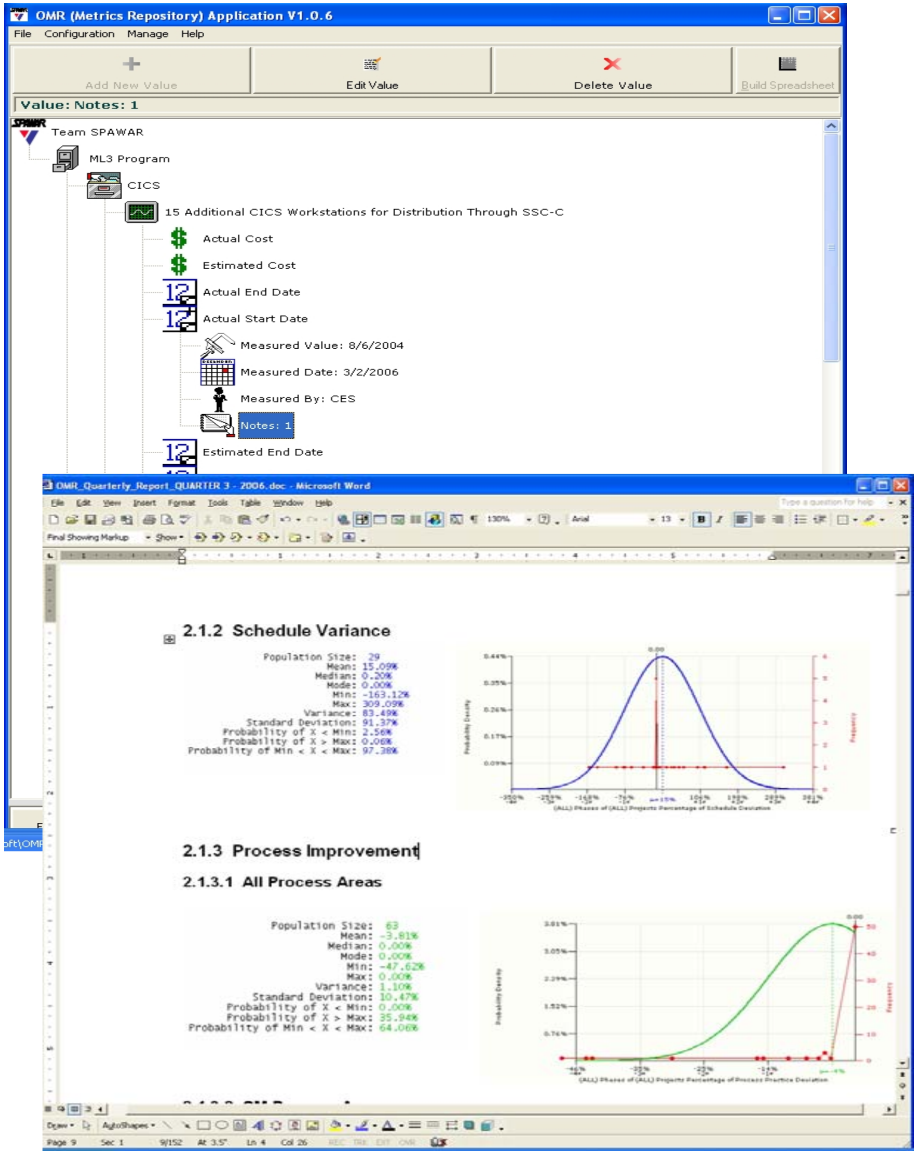
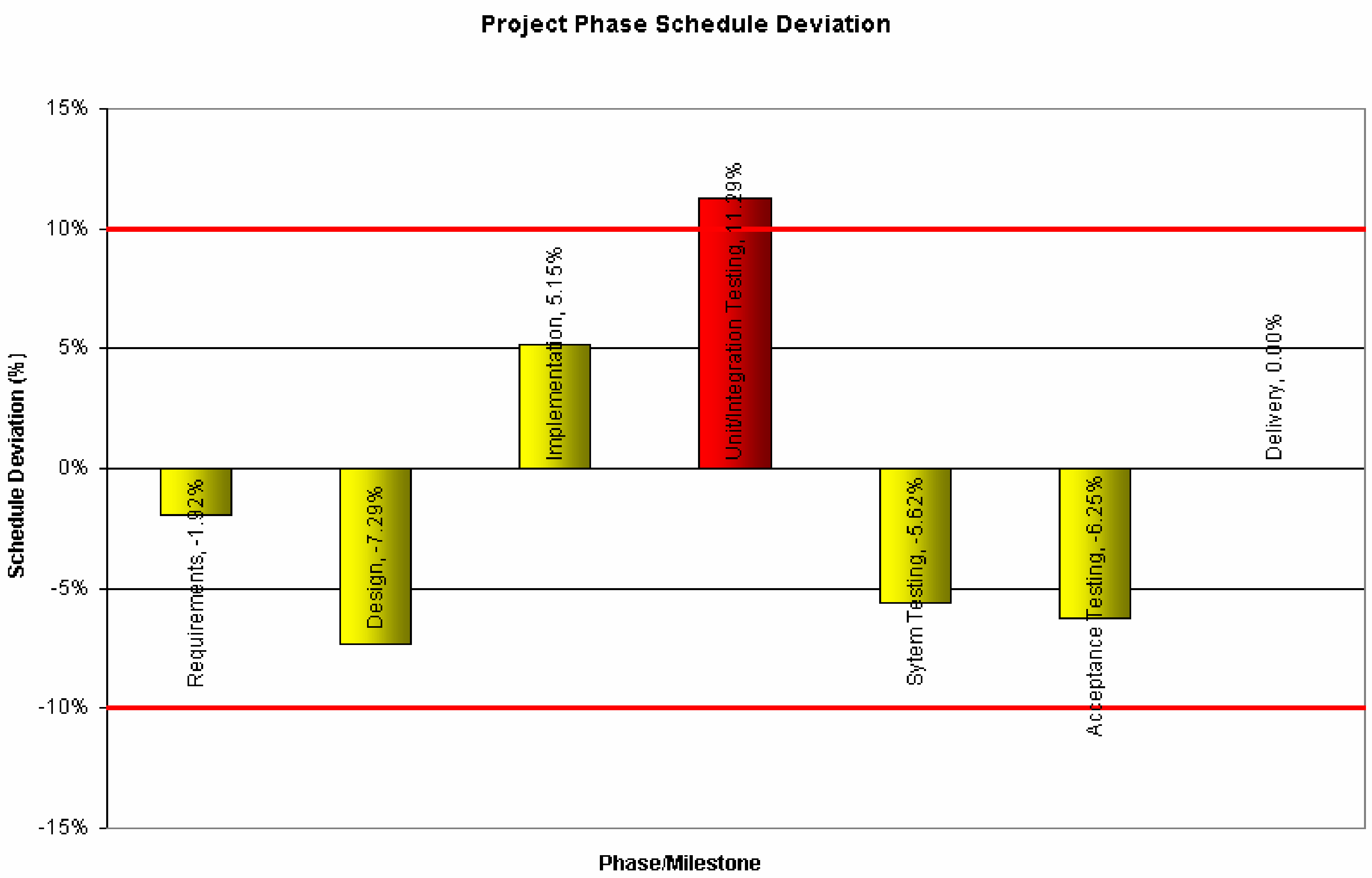
OMR Application

- **Provides interface for input and query functions**
- **Generates quarterly organizational report**
- **Projects can use to manage own projects**
  - Capture standardized cost, schedule, and process performance
- **OMR implementation included hands-on training**
- **Laying the groundwork for higher maturity**



OMR Reports
Project-Level Schedule Deviation



Additional/Modified Measures To Be Implemented in OMR

Category	Core Measure
Cost Performance (More granularity)	• **Government vs Contractor budget** – ODC – Travel – Training – Materials
Quality	• **Peer Reviews** – Effectiveness – ROI (hours expended vs hours saved) • **Pre-Deployment Defect Detection/Prevention** – Defect decrease for successive phases – PITCO vs SOVT defects • **Post-Deployment Defects**

Need improved project and organizational measures to address Maturity Level 4/5 requirements

SPAWAR

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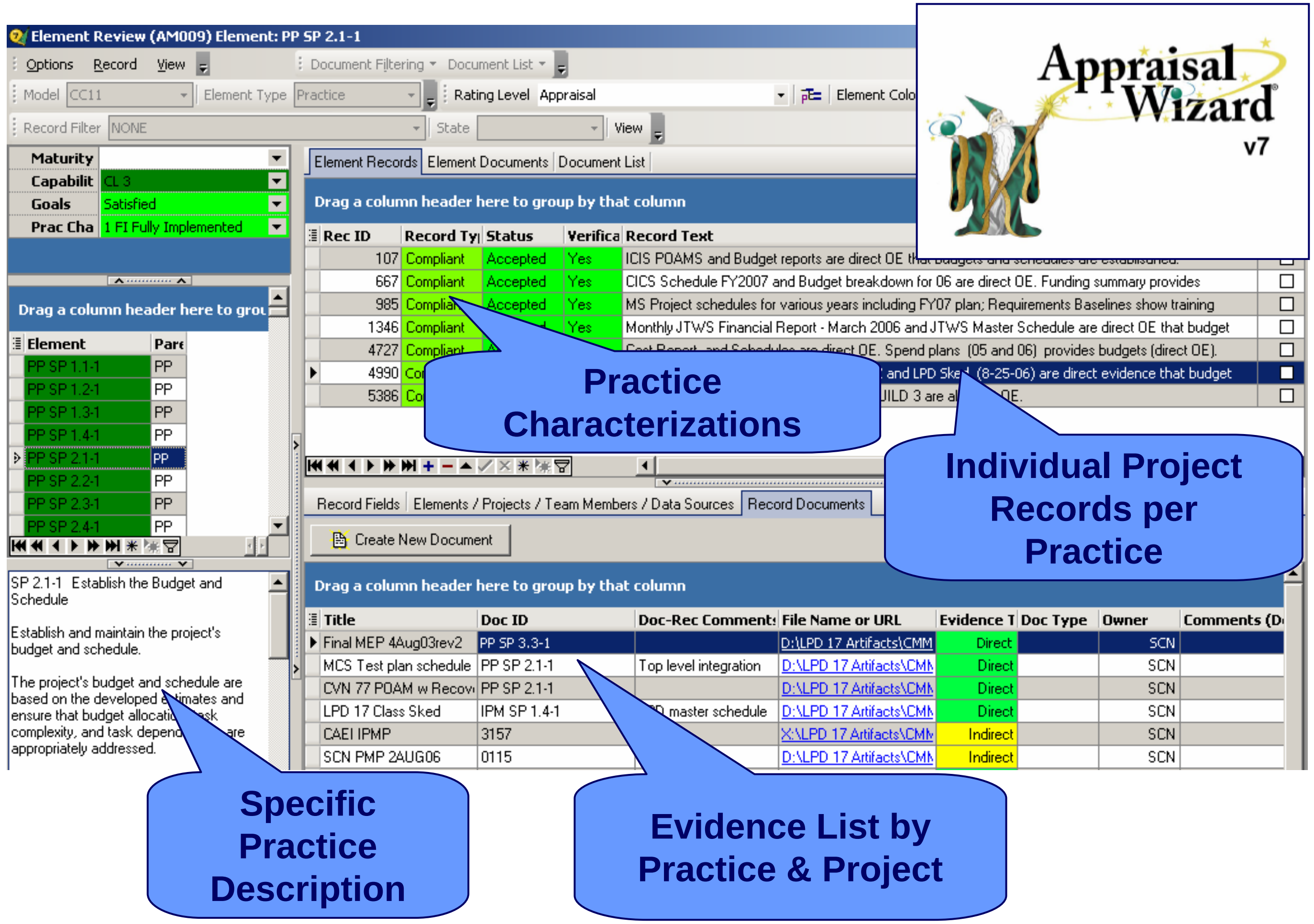
Appraisal Wizard Tool Used for SCAMPI Appraisals

- Designed for CMMI appraisals
- Link to project documents
- Easy to configure
- Captures team comments
- Improves efficiency of appraisal team



Appraisal Wizard is a product from Integrated Systems Diagnostics, Inc.

http://www.isd-inc.com

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Training

- Training Architecture
- Courses

SE & PI Training Architecture

Foundation of PI and CMMI®

- PI WBT → SEI Intro to CMMI® 3-day

Core SSC-C project and engineering processes (Level 2 and 3)

- Engineering Project & Process Mgmt Workshop
- SE for Managers
- SEMP Workshop
- SE Fundamentals
- Intro to Software Engineering
- SE 101 WBT
- Architecture Dev. WBT
- Risk Management WBT

Subject Matter Experts - Use commercially available on-site classes

- Quality Engineering
- Risk Management
- Requirements Analysis

Prepare Projects for BSC or SCAMPI

- Appraisal & Assessment Workshop

Legend:
- Existing
- Existing - revise
- New - develop
- New - buy

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Intro to Process Improvement WBT

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Originally given as a podium course, converted to Web Based Training in 2004

Now required for all employees

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SEI Intro to CMMI® for SSC-C

Taught on-site since Apr. 2004

- **3-day *Introduction to CMMI®* course teaches the full CMMI® model**
  – Students learn how the best practices build and relate across process areas
  – Learn the terminology
- **SEI-Authorized instructors are well-versed in our implementation to augment material with SSC-C specific content**
  – Highlight SSC-C tools and resources
  – Actively involved in projects, teams, and infrastructure
- **Over 350 employees trained**
  – Want to build a cultural foundation within the engineering departments

Systems Engineering Training

3-day on-site, classroom course

- Based on SMU SE Masters course
- Customized to incorporate SSC-C SE process
- Over 340 SSC-C engineers trained

1-day SE for Managers course added

- Over 60 SSC-C managers trained

Began in Dec. 2004

"It was extremely beneficial to have a professor with extensive knowledge of the subject matter and one who could apply it to the SPAWAR methods."

"The most positive aspects I took from the class was the visual correlation with what was asked for and what was produced."

"I would recommend it to all the program leads/engineers."

Student Feedback

New On-Site Courses

- **Risk Management**
  - Piloted in September, 2007
    - 4-day course
  - Designed for Risk Managers or Project Managers
- **Engineering Project & Process Mgmt Workshop (aka SE Process Improvement)**
  - Focus on how to use the SSC-C processes on your project
    - Using ePlan Builder to develop plans
    - How to establish your CM and PPQA procedures
  - Round 2 of curriculum review completed in September
- **Quality Assurance (FY2008)**
  - Initial discussions held with ASQ certified instructor to tailor course for Quality Managers at the project level

Web Based Training (WBT) Modules

- **Developed to directly meet SSC-C's needs**
  - Embedded links directly to SSC-C documents and SOPs
  - DAU too ACAT-level/large program oriented
- **WBTs feature extensive branching and rollovers**
  - Better course flow and maintains interest
  - Provides more detail for those interested
- **Audio summary on many pages**
- **Bookmark progress – come back later**
- **Courses developed to be NMCI and 508 compliant**
  - Utilize HTML, JavaScript, and ASP pages with SQL Server database
  - Designed for Internet Explorer (5.5 +), Flash (5.0 +), Windows Media Player (9.0 +)

Introduction to Systems Engineering

– 10-module web-based training (~16 hours)

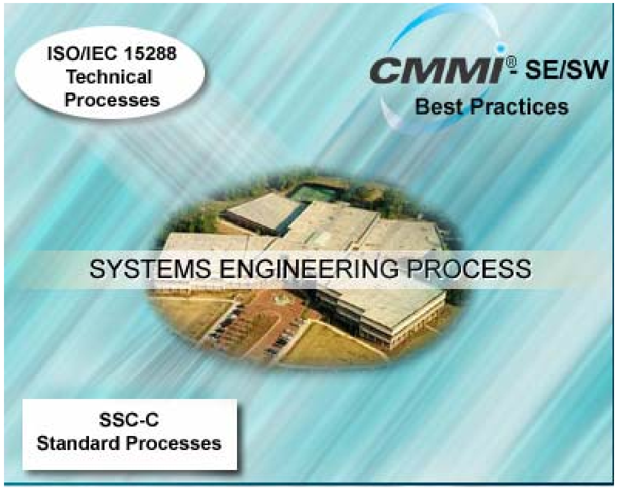
– Closely aligned to SSC-C SE Process, SE Fundamentals Course, ISO/IEC 15288 and IEEE standards

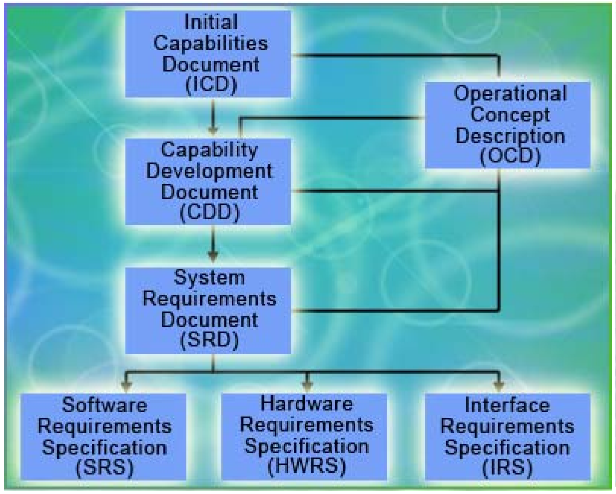
– Includes hotlinks to referenced documentation

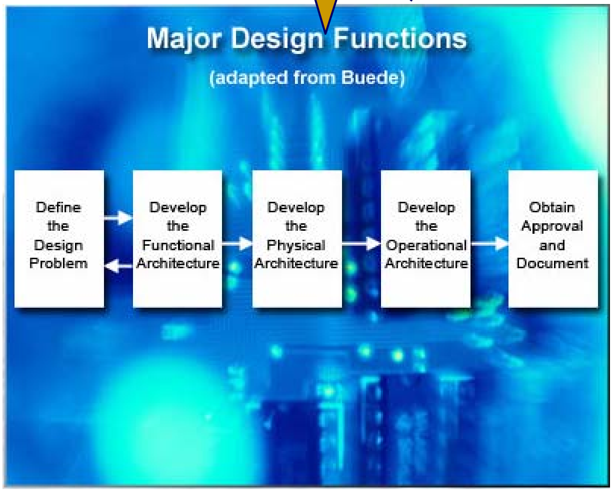
  • Process manuals, policies, standards

  • Great for Topic-specific refresher training

Released in Jan. 2006

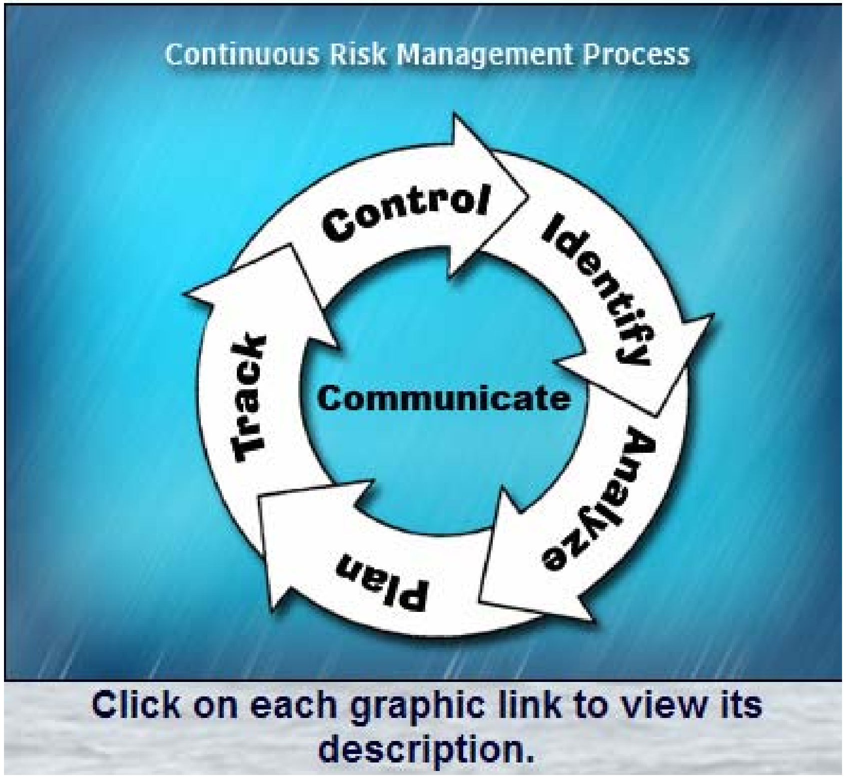






Risk Management WBT

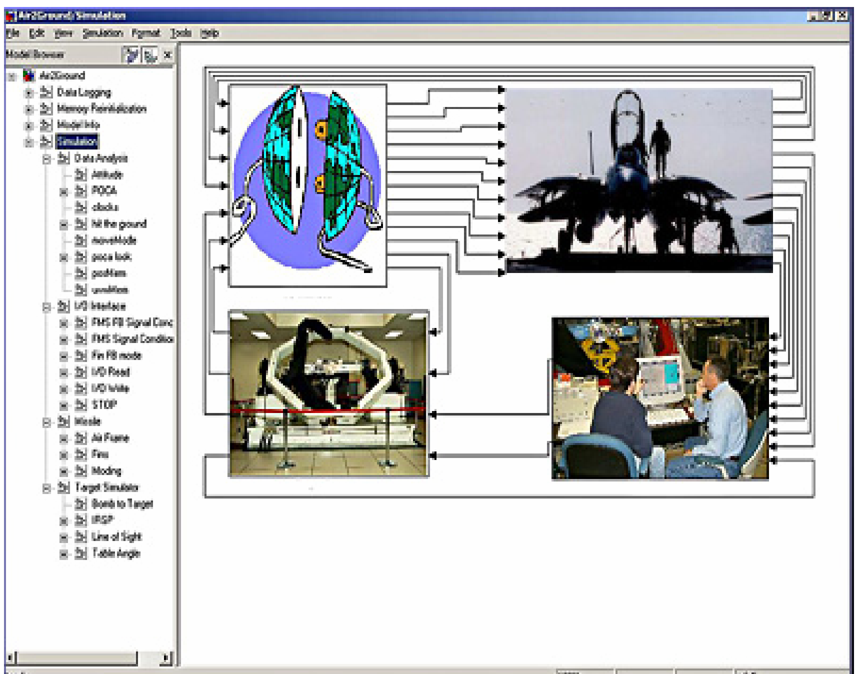
- **Topics**
  - Risk identification
  - Analysis tools and techniques
  - Mitigation planning
  - Risk monitoring
- **Section Test Questions**
- **Hot Links to Examples**
  - SSC-C Formats
  - Project Risk Reports
  - Tools
  - DAU / External resources

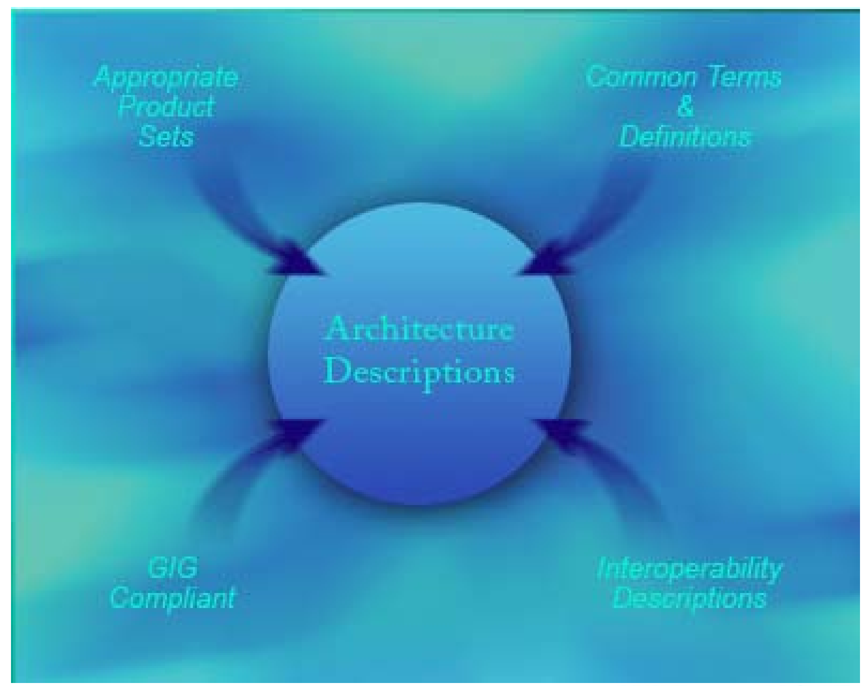


More relevant and understandable for SSC-C than the DAU module

Architecture Development WBT

- **Introduction to Architecture Development and DoDAF**
  - Designed to educate and promote value of system architecture to non-architects and new engineers
  - Tests for understanding after each section





Summary and Results

What We Have Accomplished

- **Process Focus**
  - Defined Policies and Processes
  - Aligned with DoD and SPAWAR guidance
  - Aligned with industry standards and CMMI® model
  - Built organization structured around processes and process improvement
- **Training is Critical**
  - Providing Fundamentals of Engineering for new and old professionals
  - Developed web-based training for “self-paced” and refresher training
  - Defining a structured technical career development path for engineers
- **Tools for the Engineers**
  - Developed *ePlan Builder* application to generate planning documents
  - Developed templates, checklists, and web-based document repositories to link standards and DoD guidance to day-to-day tasks and processes

Early and persistent Systems and Software Engineering applied to programs and projects

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Lessons Learned

- **Senior Management support is critical to success**
- **Training**
  - Everyone needs to be engaged – “train the masses”
  - Specific training for process owners/subject matter experts
- **Utilize Teams (IPTs) as champions of specific processes**
  - Multi-department representation
  - Change agent mentality
  - Process-focused charters
- **Resource Properly**
  - Implement with projects that want to improve, can benefit from efforts, and that recognize own weaknesses
  - EPO staff provided skilled coaching, resources, support, and tools
  - Project members learned by doing and maintaining
- **Goals and Publicity**
  - Keep goals to sizable bites (projects)
  - Publicize successes; Share best practices

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Is the SE Revitalization Working ?

- **Recognition of SE and CMMI effort**
  - 1st SPAWAR Systems Center to achieve Maturity Level 2 (2005)
  - 1st SPAWAR Systems Center to achieve Maturity Level 3 (2007)
  - Multiple presenter at NDIA SE and CMMI conferences
    - High interest in Tools, Training, and Implementation

Is the SE Revitalization Working ?

- **Business Results**
  - SCN: “They see us as a model and want to increase our efforts.”
  - Automation Program: “We had hundreds of sites and there was a need for a structured organization to put a ‘wrapper’ around that and control it. CMMI became the wrapper.”
  - CICS: “CMMI was key to achieving the project goal.”
  - VIDS: “The VIDS failure (2000) motivated implementing CMMI because the team needed to change course or the customer would have no confidence in system development. It was a tremendous success…”
- **Others Asking for Help**
  - PMS 408 – CREW program
  - SESG / NAVAIR / NAVSEA
  - Marine Corp – Quantico
  - Air Armament Center, Eglin AFB

Going Forward

- **Increase usage of tools across departments/projects**
- **Add additional plans to ePlan Builder as needed**
- **Continue internal CMMI Level 3 mini assessments**
- **Enhance/Expand OMR**
- **Command and Department Project Reviews process**
  - Look at quality of plans and implementation of best practices
  - Reviews of project status by management driven by project metrics
  - More Peer Reviews to measure "saves"
- **Better tailoring guidance for smaller projects**

Begin Maturity Level 4/5 implementation

Any Questions?

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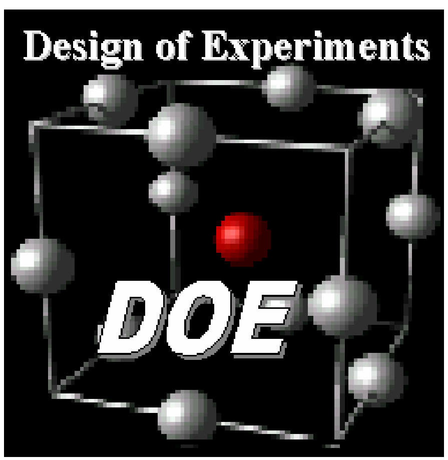
10th Annual NDIA Systems Engineering Conference
22-26 Oct, 2007, San Diego, CA

Applying Design of Experiments (DOE) methodology to Sortie Generation Rate (SGR) Evaluation



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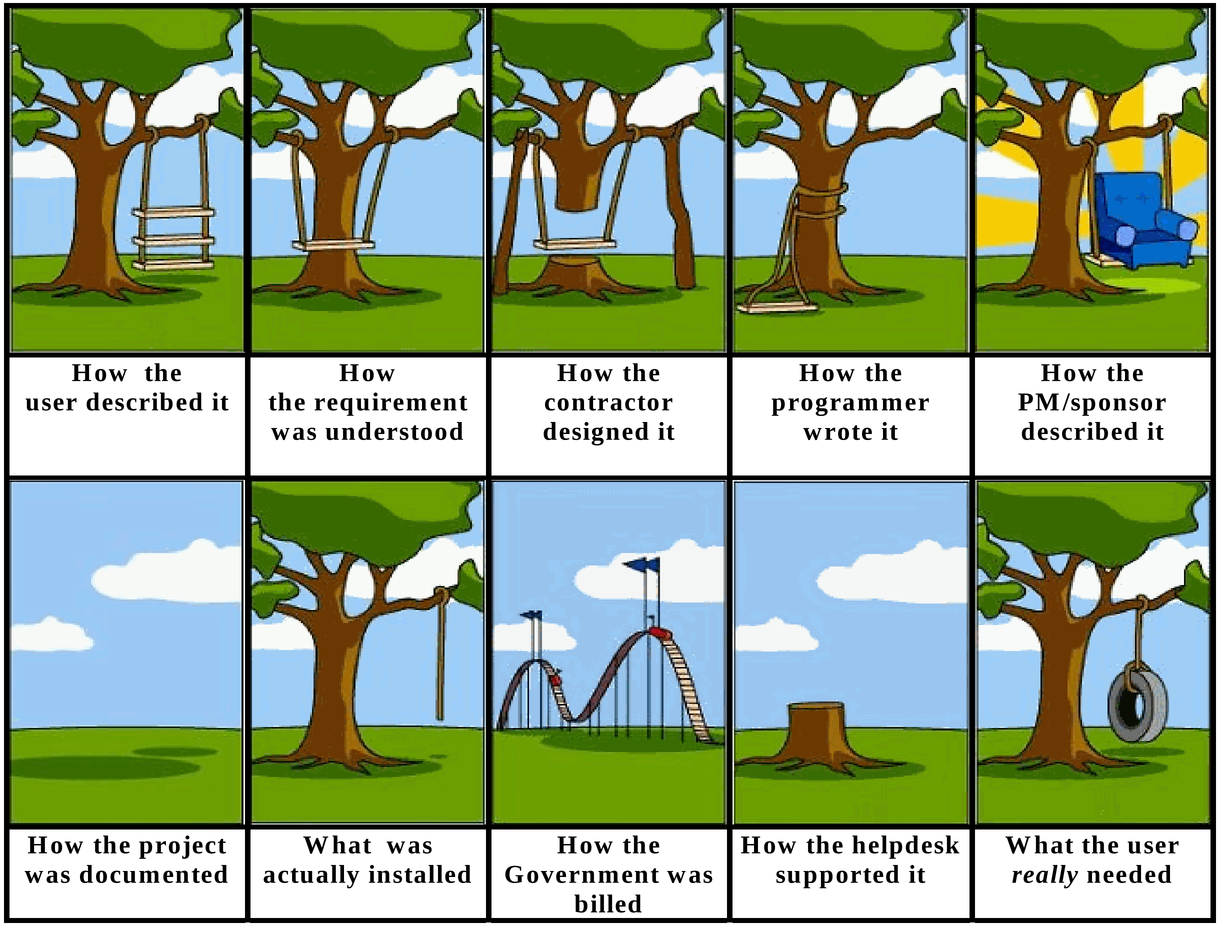
Agenda

- Introduction
  - Acquisition humor
  - The Integrated T&E Challenge
- Intro to Design of Experiments
- SGR Assessment Methodology
  - Overview of SGR Assessment to date
  - SGR Assessment objectives, MOEs, factors
  - SGR Testbed Assessment Design Factors / Run Matrix
  - SGR Live Testing Validation
- Benefits of DOE over single scenario based analysis
- Conclusion / Q&A

NOTE: My remarks are intended to spur thought on improving how we as testers can do business better to support the warfighter. While I hope this aligns well with DoD and Services T&E initiatives, I am not representing any government agencies' official position.

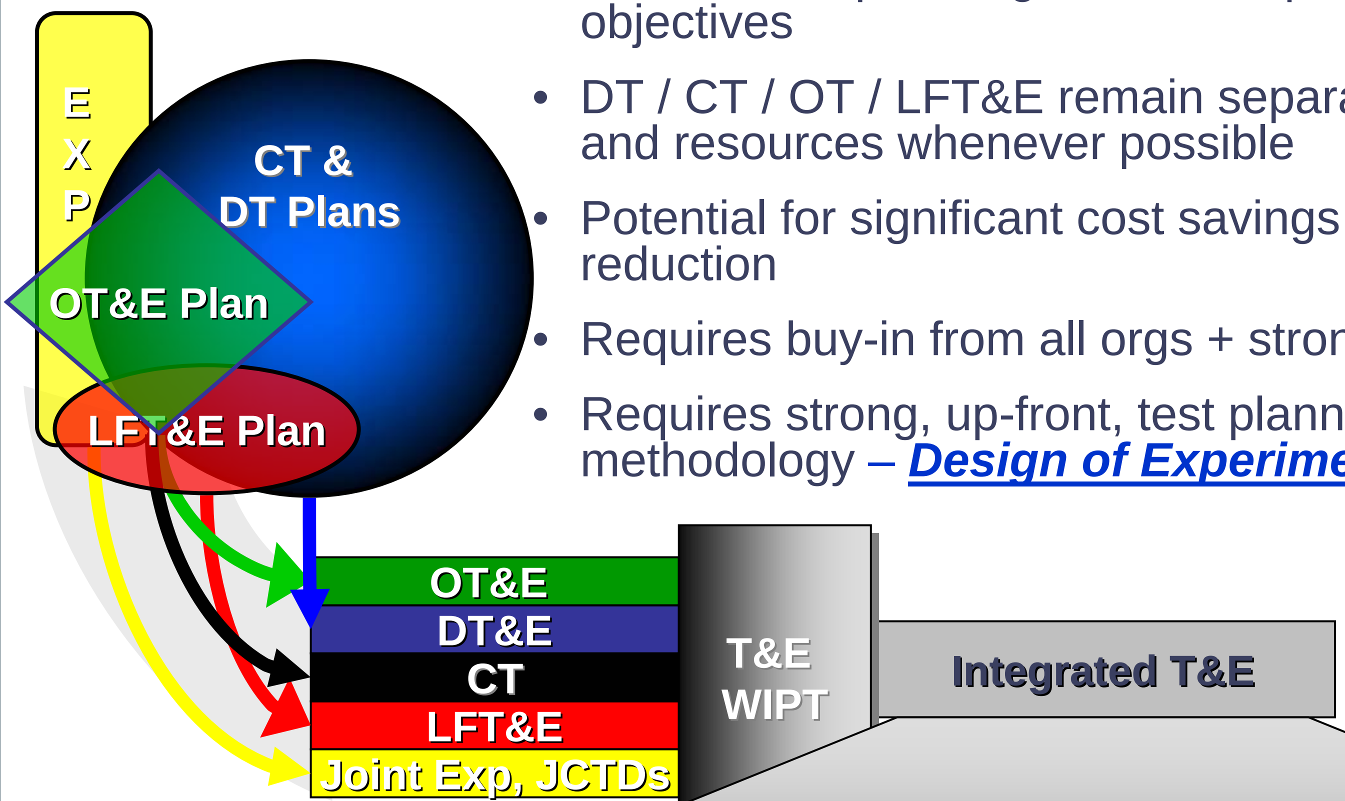
Acquisition 101?



How do we avoid this?

Integrated T&E Challenge

- Coordinated planning and development of individual test objectives
- DT / CT / OT / LFT&E remain separate but leverage data and resources whenever possible
- Potential for significant cost savings and earlier risk reduction
- Requires buy-in from all orgs + strong T&E Working IPT
- Requires strong, up-front, test planning and data analysis methodology – ***Design of Experiments (DOE!)***



$$T\&E_{integrated} \int_{\text{Program Conception}}^{\text{System Disposal}} = f\,(CT, DT, OT, LFT\&E, \text{Joint Exp}, M\&S, \text{Analysis, etc.})\; dt$$

Intro to DOE

Background of DOE

- DOE originated in the field of agricultural studies in the 1930s by R. Fisher, building on W.T. Gossett’s work at Guinness Brewery—Brilliant!
- Used throughout industry in industrial experiments, process improvement, statistical process control
- USAF has significant experience in use of DOE across numerous programs; Navy is beginning to implement
- DOE methodology is used to interrogate a process, improve knowledge of how the process works, and identify factors and interactions affecting variability of performance outcomes.

DOE Process Goal / Benefits

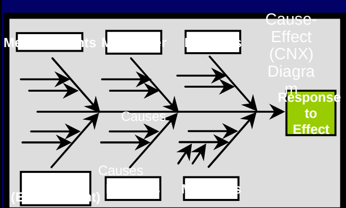
- Compared to other systematic methods DOE designs:

  - Yield better process understanding
  - Can be planned and analyzed faster
  - Cheaper – using between 20-80% of usual runs/tests/resources
  - Better exploration across range of performance—depth and breadth of testing
  - Challenge assumptions and demonstrate real performance
  - Better way to design and test complex systems

DOE Process Outline—
4 Basic Steps

- **Project description and decomposition**
  - Problem statement and objective of experiment (test)
  - Response variables, and potential causal variables – Ishikawa fish bone.
- **Plan test matrix**
  - Determine constraints, prioritize factors, and select statistical design (2^K vs. 3^K vs. mixed, Taguchi vs. classical arrays, full vs. fractional, non-linear effects?, replications?, blocking?)
  - Write the test plan with sample matrices, profiles, and sample output; run sample analysis.
- **Produce observations** –random run order & blocked against unknown effects
  - Block runs to guard against uncontrollable unknown effects as needed.
- **Ponder the results**
  - Analyze and project data; draw conclusions, redesign test as necessary and assess results.
  - Perform "salvo testing" (test-analyze-test); screen large # of factors then model

Process

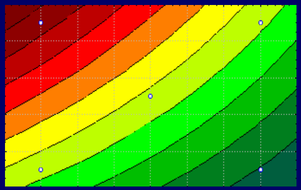


Plan

		In Front		In Back	
		Face East	Face West	Face East	Face West
Eyes Open	Left Hand	0.43	0.58	0.52	0.40
	Right Hand	0.62	**0.29**	**0.28**	**0.36**
Eyes Closed	Left Hand	0.62	0.57	0.47	0.40
	Right Hand	0.42	**0.26**	0.42	0.47

Produce

Ponder



SGR Assessment Methodology

AVW TECHNOLOGIES

SGR Assessment Requirements

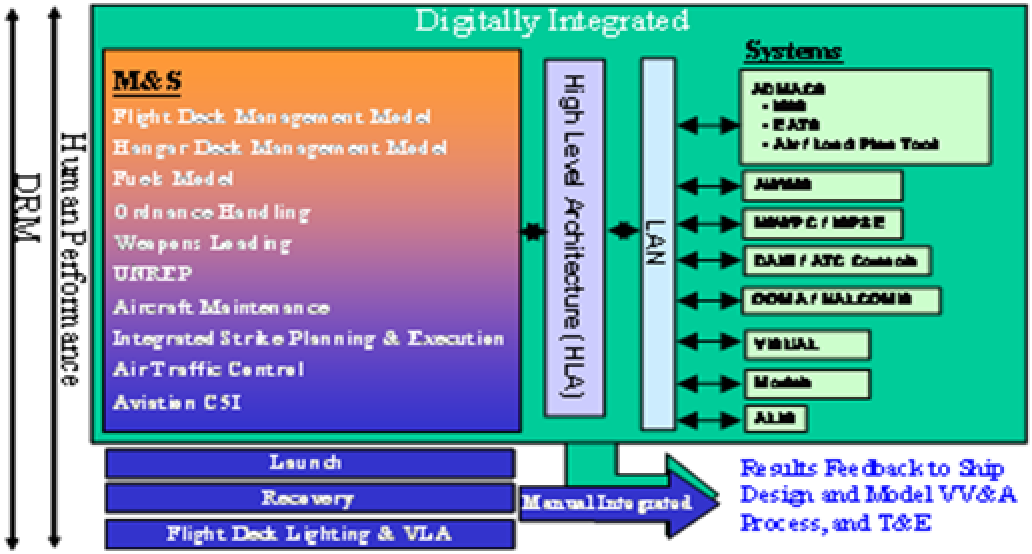
- **SGR Key Performance Parameter**

	THRESHOLD	OBJECTIVE
Sustained SGR	Average of 160 operational combat equivalent aircraft sorties in 12 hours of launching per day over 30 days (26 Flying and 4 Non-Flying Days as specified in the Design Reference Mission (DRM) – total cycle of 4160.	Average of 220 operational combat equivalent aircraft sorties with 12 hours of launching per day sustained over 30 days (26 Flying and 4 Non-Flying Days as specified in the DRM) – total cycle of 5720.
Surge SGR (requires crew augment)	Average of 270 operational combat equivalent aircraft sorties generated during each successive 24-hour period over 4 continuous days.	Surge: average of 310 operational combat equivalent aircraft sorties generated during each successive 24-hour period over 4 continuous days.

- **Other Measures of Performance:** cycle times, task timing, launch and recovery cycles, resource usage, crew fatigue levels, fuel states/rates, etc.

SGR Assessment Testbed

- M&S testbed captures times and actions associated with preparing, launching, and recovering sorties per the DRM



- M&S matured and validated over time prior to runs for score
- Live test used for validation once ship is delivered and aviation certified

AVW TECHNOLOGIES

SGR Model

SGR is a function of

- Launch Cycle/Interval Timing
- Recovery Times/Intervals
- Mission Planning Timing
- Aircraft Recovery Time Which Encompasses:
  - Fueling Time
  - Ordnance Handling Times
  - Aircraft Movement/Spotting Times On The Flight Deck
  - Aircraft Movement/Spotting Times In The Hangar Bay
  - Aircraft Availability

SGR Assessment Analysis Objectives

- Determine average SGR over DRM to meet KPP requirement
- Determine active factors influencing the variability & overall outcome
  - Measure % sorties completion rather than binomial pass/fail
  - Each day in the DRM treated as a single design point due to interdependencies of events within that day
- Provide the fleet with an analytical model showing probability of meeting a given airplan based on its size, mission composition, environment, and any other active factors

$$\%Airplan\_Sorties\_Completed = \frac{Daily\_sorties\_completed\_succesfully}{Airplan\_sorties} x100\%$$

- Allows equal comparison of the 4 T/O surge/sustained requirements across all factors
- Continuous dependent variable provides more statistical power than pass/fail
- Supports more robust assessment of capes and lims

SGR Factor Selection

Experimental control factors:

- Environmental
  - Sea/Winds: state 1 vs. 3
  - Visibility/Sky Cover: Clear Skies (Case I) or Cloudy/Night (Case III)
  - Time of day: midday or midnight (for 12 hour ops, N/A for 24 hour ops)
- Systems:
  - Availability: 100% & actual (for CVN-21 systems and aircraft)—allows for analysis of impact of equipment failures
- Mission
  - Sortie Size: Threshold & Objective levels from the DRM
  - Sustained and Surge Mission (12 vs. 24 hr ops (with augmented crew))
  - Operation day: early and late in ship on-station operational period; expect to interact with availability for system failures and also translates to possible crew fatigue
  - Airplan mission mix: early/late DRM days representing different ordnance mix;
  - Mission mix and operation day

SGR Factor Selection (cont')

Controllable Factors held constant:

- Underway Replenishment
  - Not a factor of SGR but presumed to occur on assigned days or fuel and ordnance will not be available for the planned flight days)
- Aircrew augmentation
  - Confounded with mission type – assumed normal crew for sustained operations and augmented crew for surge missions

Measurable Noise Factors

- Other environmental factors not controlled (if in test / model)
  - Temperature extremes
- Specific metrics in the subordinate models driven by the main inputs, such as:
  - Crew fatigue (driven by the mission day)
  - Resource availability
  - Number of aircraft available
  - Weapon skids available
  - Timing for critical tasks, etc.

AVW TECHNOLOGIES

SGR Factor Selection (cont')

- Design factors:
  - Factors with highest expected influence listed first
    - Important when setting up fractional factorial matrices—usually easier to resolve factors and interactions
  - Setup for M&S only; cannot test all of these in live testing
  - Requires M&S improvements
  - Need buy-in for "excursions" above threshold
    - High levels force the "system" towards a higher failure rate to see more variation in response

Setting Factor		**(Low) -1**	**(Center Point) 0**	**(High) +1**
A	Surge/ Sustained Operations	Sustained (12 Hr ops)	N/A	Surge (24 Hr ops w/augment)
B	Sortie Size (T/O)	Thres-hold	Halfway btwn	Objective
C	operational day	Early (1/4 or 5/30)	Mid (2/4 or 15/30)	Late (4/4 or 26/30)
D	Availability	100%	Halfway btwn	actual/ spec
E	Visibility/ Cloud Cover:	Clear/ Case I	Partly Cloudy/ Case II?	Cloudy/ Case III
F	Seakeeping motion effects	5 kts/SS1	12 kts/SS2	20 kts/SS 3
G	Time of day	Day	Dusk?	Night
H	Mission Day	Early	Mid	late

AVW TECHNOLOGIES

SGR Testbed Run Assessment Design

- Full factorial requires 2^8 or 256 runs
  - *Unnecessary since many effects are inactive*
- Resulting test matrix is a resolution IV 2^{8-4} fractional factorial of 16 runs + 8 additional runs for central composite design
  - *Some interactions are confounded but can be resolved*
- Model DRM days per the assigned settings and evaluate SGR Compl %
- "salvo test":
  - Runs 1-8, then analyze for effects
  - Runs 9-16, then reanalyze for effects
  - Perform center points to check for linearity
  - If necessary, run CCD (face points) for non-linear effects

Run		Blk	A	B	C	D	E = ABD	F= ACD	G= BCD	H= ABC
1	Factorial	1	-1	-1	-1	-1	-1	-1	-1	-1
2	Factorial	1	-1	-1	-1	+1	+1	+1	+1	-1
3	Factorial	1	-1	-1	+1	-1	-1	+1	+1	+1
4	Factorial	1	-1	-1	+1	+1	+1	-1	-1	+1
5	Factorial	1	-1	+1	-1	-1	+1	-1	+1	+1
6	Factorial	1	-1	+1	-1	+1	-1	+1	-1	+1
7	Factorial	1	-1	+1	+1	-1	+1	+1	-1	-1
8	Factorial	1	-1	+1	+1	+1	-1	-1	+1	-1
9	Factorial	2	+1	-1	-1	-1	+1	+1	-1	+1
10	Factorial	2	+1	-1	-1	+1	-1	-1	+1	+1
11	Factorial	2	+1	-1	+1	-1	+1	-1	+1	-1
12	Factorial	2	+1	-1	+1	+1	-1	+1	-1	-1
13	Factorial	2	+1	+1	-1	-1	-1	+1	+1	-1
14	Factorial	2	+1	+1	-1	+1	+1	-1	-1	-1
15	Factorial	2	+1	+1	+1	-1	-1	-1	-1	+1
16	Factorial	2	+1	+1	+1	+1	+1	+1	+1	+1
17	Center rep 1	3	-1	0	0	0	0	0	0	0
18	Center rep 2	3	-1	0	0	0	0	0	0	0
19	cd face point –b	4	-1	-1	0	0	0	0	0	0
20	cd face point +b	4	-1	+1	0	0	0	0	0	0
21	bd face point –c	4	-1	0	-1	0	0	0	0	0
22	bd face point +c	4	-1	0	+1	0	0	0	0	0
23	bc face point –d	4	-1	0	0	-1	0	0	0	0
24	bc face point +d	4	-1	0	0	+1	0	0	0	0

SGR Live Testing Validation Test Design

- Live test conditions and cost (potentially $100M?) limit amount of live test and the conditions
- Focus on validating specific test points of interest and confirm within the M&S runs for score

Factor		-1	0	+1	Rationale
A	Surge/ Sust. Ops	**Sustained**	N/A	**Surge**	Both operations can be run
B	Sortie Size (T/O)	**Threshold**	**(T+ O)/ 2**	**Objective**	A mix of sortie sizes can be run
C	Operational day	**Early**	Mid	Late	No means of imposing a late day due to cost
D	CVN-21/A/C Ao	100%	Halfway	**Actual**	Actual equipment Ao
E	Cloud Cover	**Actual conditions?**			
F	Sea-State	**Actual conditions?**			
G	Time of day	**Actual conditions?**			
H	DRM Mission mix	**Early**	**Mid**	**Late**	Factor is probably inactive so randomly assign

SGR Live Testing Validation Test Design (cont')

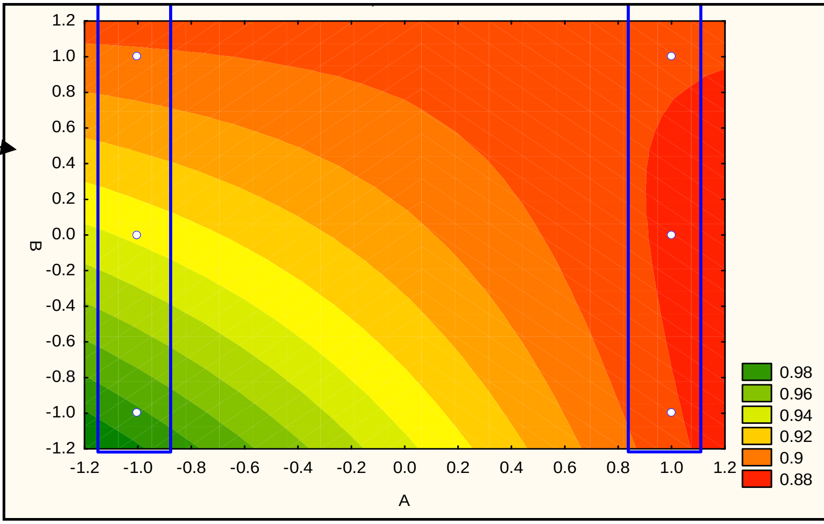
- Final Test Matrix with settings:

Test Case	A: Ops Type	B: Sortie Level	*Actual (# Sorties)*	H: DRM Mission Day	Notes
1	Sustained	Threshold	*160*	5	**Priority**
2	Sustained	Objective	*220*	26	**Priority**
3	Surge	Threshold	*270*	26	**Priority**
4	Surge	Objective	*310*	5	**Priority**
5	Sustained	Halfway btwn	*190*	15	Additional run for midpoint
6	Surge	Halfway btwn	*290*	15	Additional run for midpoint
7	Sustained	Threshold	*160*	26	Additional run for alternate mission mix
8	Sustained	Objective	*220*	5	Additional run for alternate mission mix

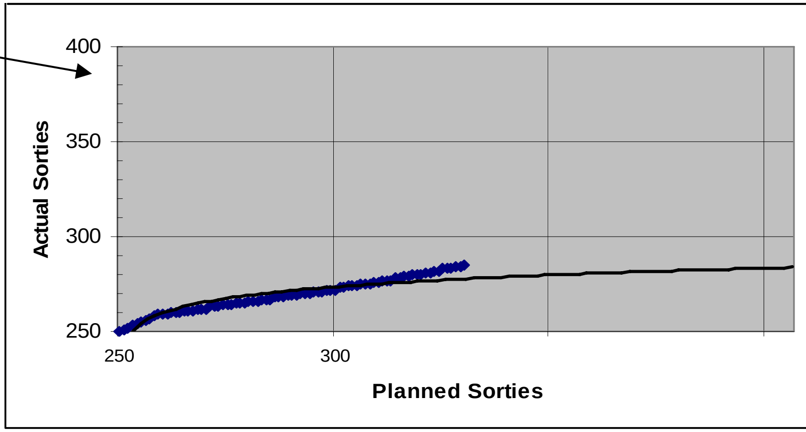
- Recommend run during Joint Task Force Exercise to ensure combat ready crew & systems
- Some analysis of variance can be run directly but main objective is to compare day for day with M&S results (including V&V of lower level measures within the specific process models)
- Runs 1-4 are priority; select additional runs based on M&S results

SGR Testbed Assessment Sample Data Analysis

- Response surface plot across factors of interest showing response & interactions



- Table of plan vs. predicted actual SGR Completion Rate for factor settings of interest -- shows SGR completion % falling off as too many are sequenced



- ***demonstrates how analysis can describe ship caps & lims, not just a pass/fail grade for a KPP tested only to threshold***

Benefits of DOE

CONCLUSION

- **DOE methodology:**
  - –*may significantly **reduce the required runs** for Testbed Assessment and live test validation while...*
  - –*providing a **more robust process** for statistical analysis of variance to determine where the ship design can and cannot support a given air-plan under the other conditions*
  - –*supports robust & efficient **integration of M&S development, testing, VV&A, & evaluation***

- **DOE is:**
  - –***a smarter way of doing testing***
  - –***can provides superior knowledge to the systems engineers***
  - –***something all testers & systems engineers should become familiar with!***
- **QUESTIONS?**

NAVAIR System Engineering Revitalization

Michael Gaydar



Briefing Agenda

- The Players-Users, Acquisition Team, & Industry
- The Environment-CDD & Contract
- The Grade-Financial & Performance
- Why We Are Here
- Current Challenges To Success
- The Death of Acquisition Reform
- Three Phase Procurement Initiative

Users

Industry

NAVAIR

Procurement Agency

The Players

CDD

Contract

NAVAIR

The Environment

Budget/Schedule

DOT&E

NAVAIR

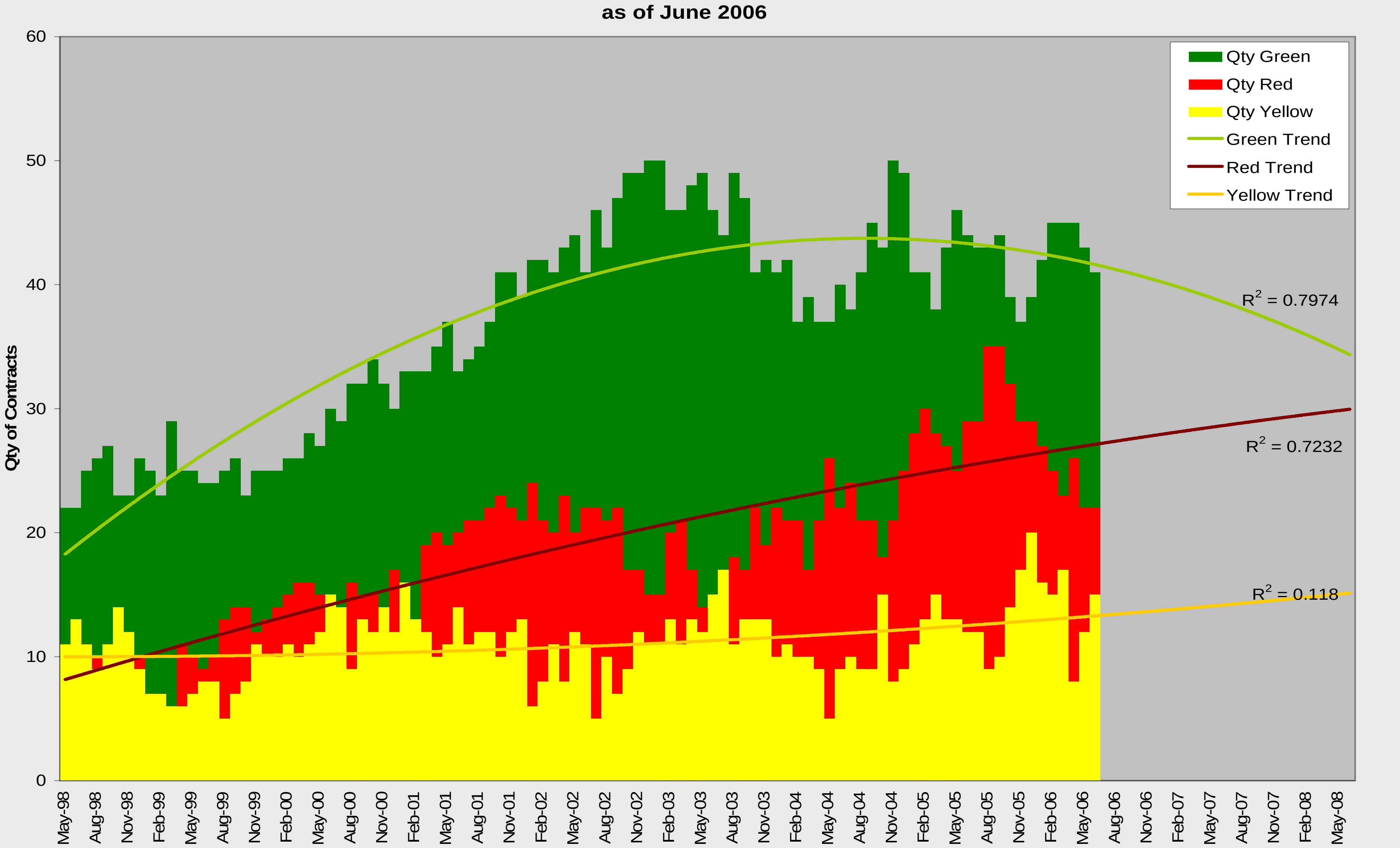
The Grade

High Visibility Programs

- Army And Navy ACS Program
- Comanche
- Littoral Combat Ship (LCS)
- Presidential Helicopter (VH-71)
- Coast Guard Deep Water Program
- Army Future Combat System
- Launch & Recovery (EMALS & AAG)
- Seal Delivery Vehicle
- CVN-78 USS Gerald Ford

NAVAIR Burning Platforms

NDIA Conference 23 Oct 2007



Stressors To Current SE Process

- **Inadequate “Pre Systems Acquisition” Phase**
  - CONOPs, OPSITs, TACSITs, Modeling & Simulation
  - Industry Involvement Required To Bound CDD
- **Specifications Lack Clarity**
  - Performance Based Specs
  - Design & Certification Standards-Non-Tailorable Requirements
  - COTS/NDI
  - Strategic View of Life Cycle Cost
- **Programmatic Stressors**
  - Cost And Schedule Set At Contract Award
  - Award Fee Schedule Promoting Bad Behavior
  - Lack Of Early Sub-Contractor Involvement
  - Government System Development Oversight

Acquisition Reform Retreat

- **Acquisition Reform Tenets Proven WRONG**
  - Broader Performance Based Specifications
    - Required Design Standards Missing
    - Certification Standards Missing
  - Less Government Involvement
  - Contractor And Government Goals Aligned
  - 90 Percent Solution Post CDD Is Acceptable
  - CDRLs And Documentation Not Required
  - Risk Identification Is A Management Tool
  - Award And Incentive Fees Motivate Contractors

New Approach

- **Clear Requirements**
  - Industry Involvement In Requirements Development
  - Design, Build, And Certification Standards
  - Derived And Correlated Requirements
  - Use Case Analysis
- **Contract Governs Communication**
  - Objective, Deliverable Evidence To Support Oversight
  - SEP Issued With RFP
  - Enforce “Event Driven” Design Maturity To A Schedule
  - IMS & EVM Is Essential Forum For SE Management
- **Government Acts As Prime Integrator Role**
- **Reality Based Budget And Schedule**

Design Review Process

Design Review	Baseline
SRR-System Requirements	Performance
SFR-System Functional	Functional
SSR-Software Specification	Software Requirements
PDR-Preliminary Design	Physical
CDR-Critical Design	Build
IRR-Integration Readiness	Integration
TRR-Test Readiness	Test
FRR-Flight Readiness	Airworthiness

MS-A   MS-B

RFP   RFP   SRR   SFR   RFP   PDR   CDR

PHASE I

Objectives/Process

- Multiple Contractors Engaged
- Develop CDD Through JROC
- Understand Non-Tailorable Specifications
- Assess Technology TRL 6
- Develop CONOPS, OPSITs, & TACSITS

Output

- Reasonably Bounded CDD
- Formal CONOPS
- USE CASE Analysis
- Conceptual Solutions
- Cost/Schedule Cut

PHASE II

Objectives/Process

- Down Select To Few Primes
- Derive System Development Specification
- Finalize Tailorable Specifications
- Apply USE CASES To Derive Funtionality
- Develop Interface Specifications
- Engage Major Sub-Contractors

Output

- Fully Derived System Development Specification
- Sub-System Specifications
- Models & Prototypes
- IBR Quality Cost & Schedule Estimates
- IMS And Initial EVM System

PHASE III

Objectives/Process

- Down Select To Single Contractor
- Traditional SDD Process
- Reduced Risk Environment
- Derived Requirement Define
- Realistic Cost And Schedule Constraints

Output

- Proceed To Normal Milestone C

Summary

- **Revitalization Goal**
  - Better Requirements Understanding And Stability
  - Better Budget And Schedule Discipline
- **Additional Phase With Multiple Contractors**
  - Supports Bounding Of CDDs
- **Control Program Inertia Into Milestone B**
- **Implementing Contracting Strategies Still In Review**

Complex Systems of Systems: The Double Challenge

Software Engineering Institute
Carnegie Mellon University
Pittsburgh, PA 15213

Philip Boxer, Lisa Brownsword,
Ed Morris
23 October 2007

Briefing Objectives and Agenda

Instigate an alternative way of viewing systems of systems

- Begin equipping participants to ask different questions about the challenges and the opportunities

Agenda

- Describe a project approach
- Explore implications of a changing world
- Describe an alternative reasoning framework

Many Organizations Have These Problems

The DoD

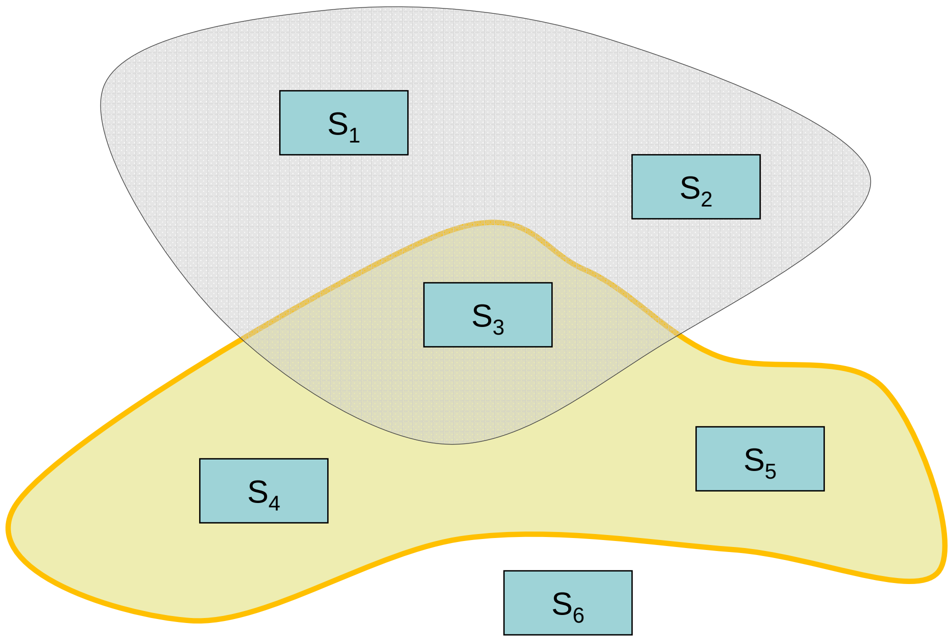
Other federal agencies

Large and small industrial organizations across the globe

Recent studies by the SEI and international consortia show that large, systems of systems (SoS) are endemic

- SoS challenge the capabilities of high-performing, high-capability organizations accustomed to large systems.
- These challenges surface throughout development, acquisition, deployment, and evolution.
- These challenges derive from working across multiple enterprises in response to rapidly changing and unanticipated forms of operational demand.

Creating, Using, and Evolving Composites of Systems



Why isn't This Straightforward?

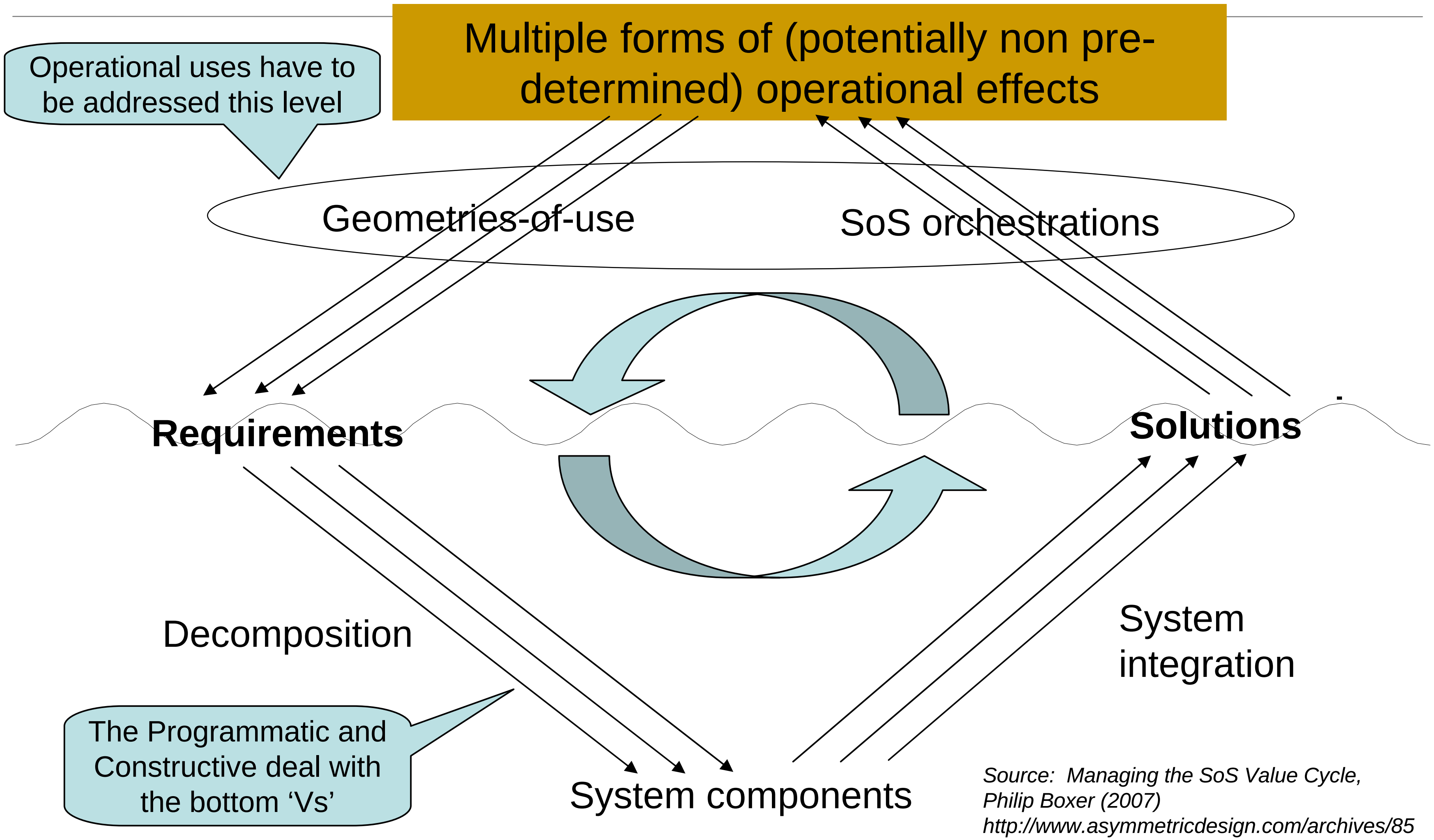
A typical approach

- Look at the software aspects of individual systems
- Determine which ones are "good" for the composite system of systems
- Determine how to put the good ones together—quickly

"Click and Clack" example

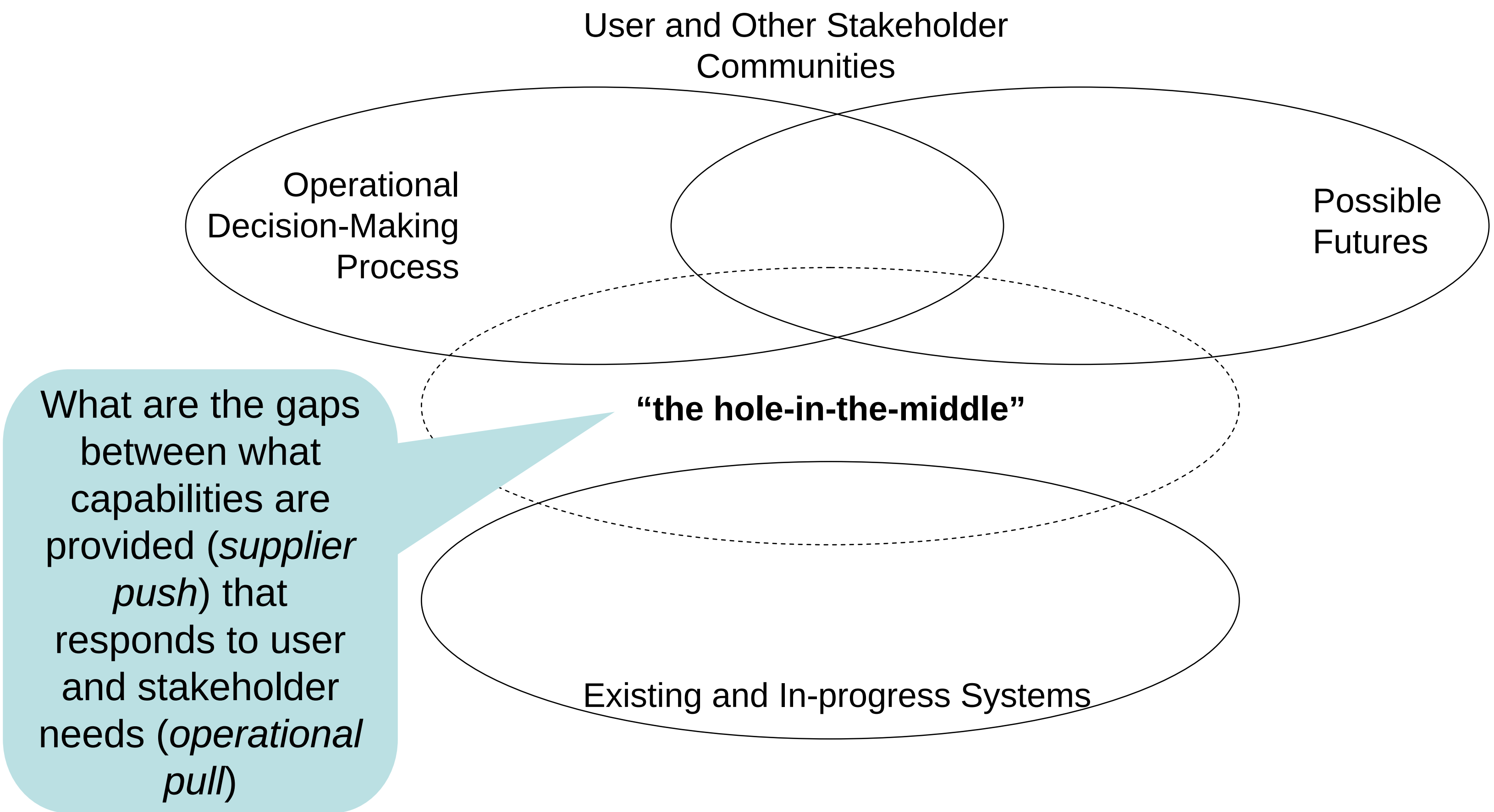
National Public Radio's *Car Talk*

What is Needed: A Concept of "Operational" that Takes a Broader View



Source: Managing the SoS Value Cycle, Philip Boxer (2007) http://www.asymmetricdesign.com/archives/85

Looking at the Situation from a System-of-Systems Perspective



Key Challenge: How Entities Work Together and Resolve Conflicts

- Number, type, and roles of participants are increasingly diverse, reflecting differing vested interests
- Scarce resources and the need for concurrent uses make a single decision authority increasingly unlikely

Single Task System

A single program directs composition; little potential for conflict

Single Enterprise System

A real or virtual entity directs how multiple entities collaborate to compose multiple programs; and resolves potential conflicts by imposing constraints

Multi-Enterprise System

Multiple real or virtual directing entities making competing demands on SoS; and conflict resolution requires negotiating mutual constraints

Category names from "Architecting Principles for Systems of Systems", by Mark W. Maier. http://www.infoed.com/open/papers/systems.htm

Key Challenge: Increasingly Turbulent Operational Contexts

- Customers and users want specialized solutions in ever shorter time frames continuously adapted to their changing and evolving situations
- Suppliers and systems have to become more agile to respond

Product-based

Users want products or services that can be provided in a way that is unaffected by how they are used

Solution-based

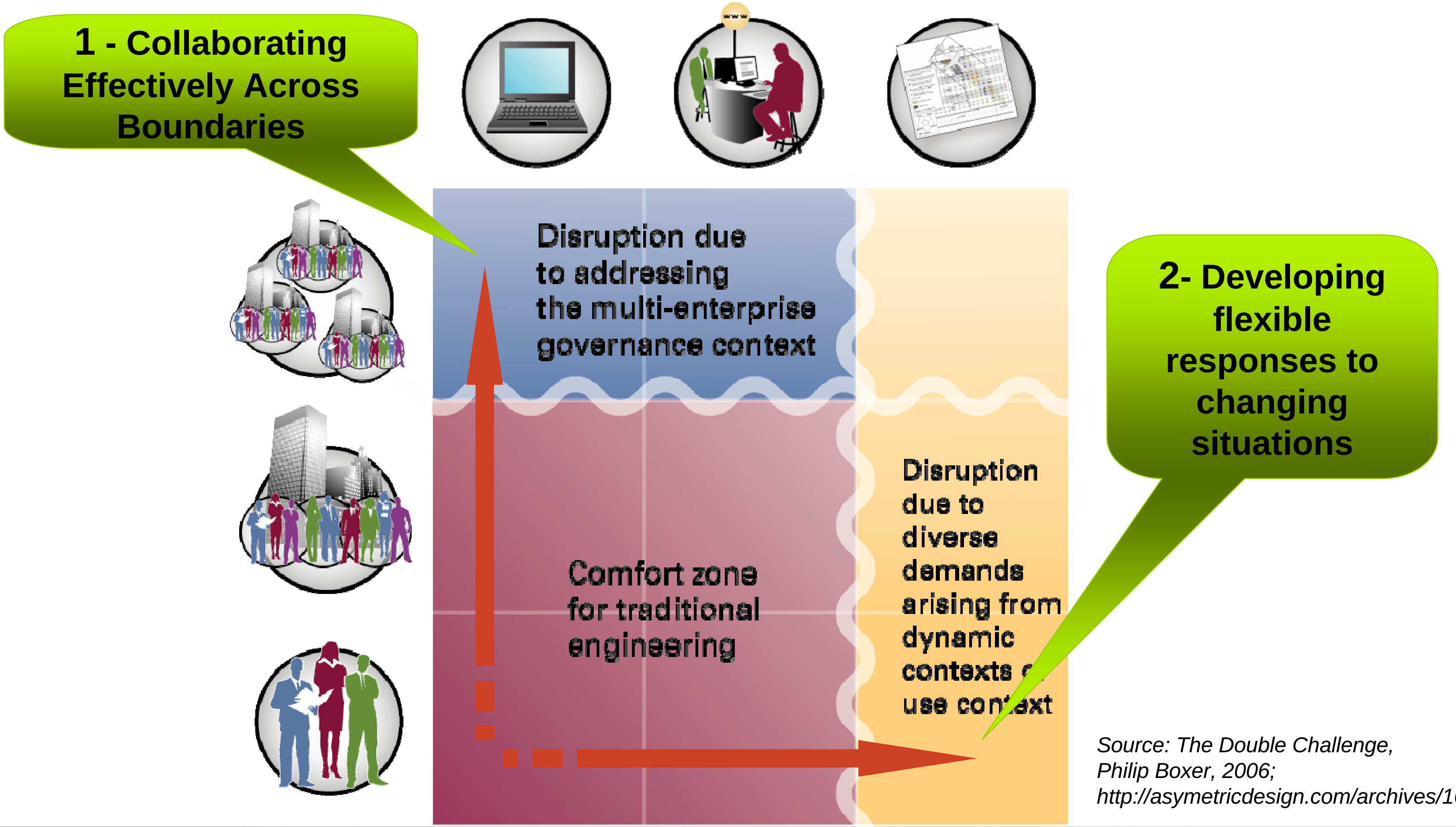
Users want integrated solutions that are customized to their context, but in a way that can be specified beforehand

Customer Experience-based

Users want integrated solutions that are customized in ways that change and evolve throughout the life of the mission that they support

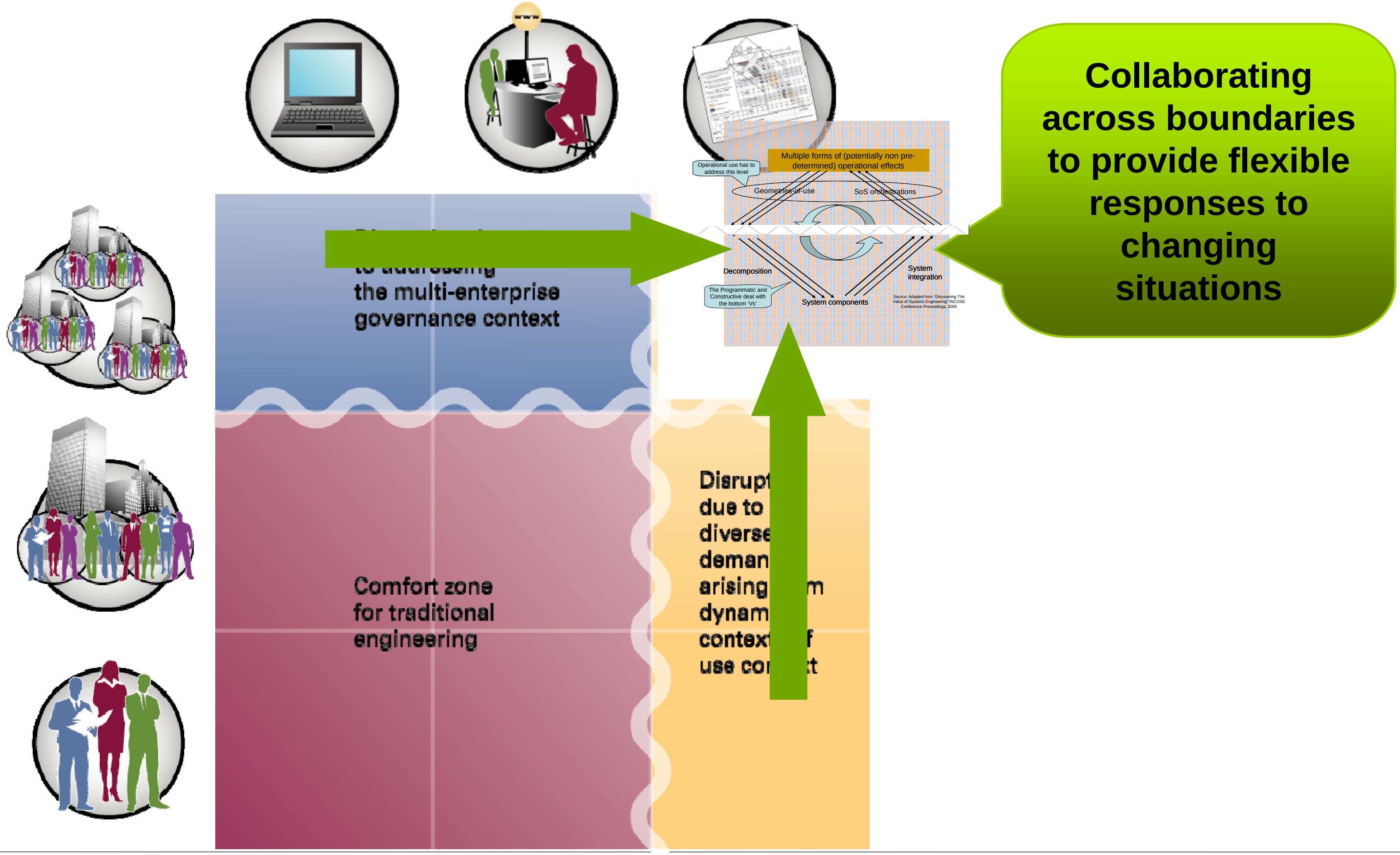
'Turbulence' as per "The Causal Texture of Organizational Environments", Emery F E and Trist E, Human Relations 1965, 18, pp 21-32.
Categories adapted from "The New Frontier of Experience Innovation", Prahalad and Ramaswamy, MIT Summer 2003

A Double Challenge: Diversity of Participants with Turbulent Usage Contexts and Needs

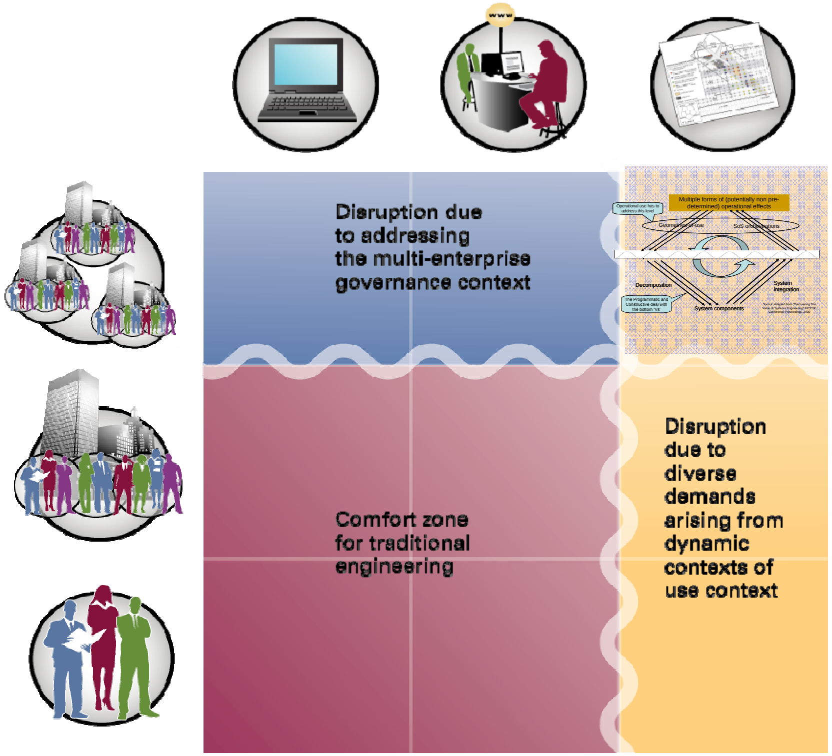


Source: The Double Challenge, Philip Boxer, 2006; http://asymetricdesign.com/archives/16

The Need: Leveraging the Double Challenges



An Example



Where were they?

Where did they need to be?

What were the gaps?

The Situation

Multi-national stakeholders in an acquisition program updating a system of systems within an operational capability

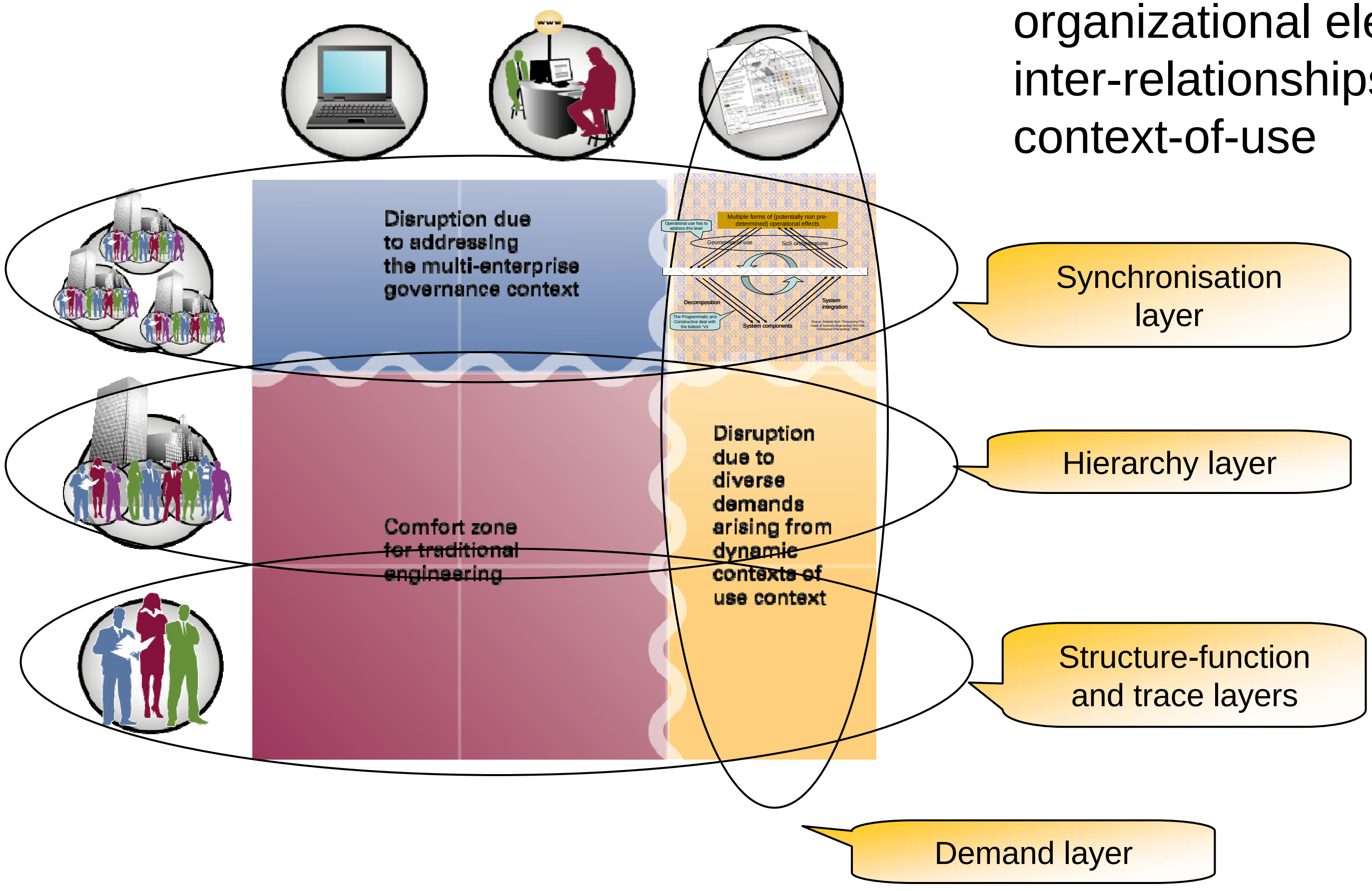
- Operational capability itself occupies a key role interoperating with other capabilities within a single unified command undertaking joint missions.
- Issue was the sustainment of the operational capability through its life given anticipated changes in its role and the complex nature of its systems.

This involved three challenges:

1. managing the process of upgrading within the context of sustaining the operational capability
2. improving the way these processes are managed through the life of the capability, given their systems-of-systems nature
3. improving the role of acquisition in support of this kind of sustainment

Modeling the Whole Space

Objective: understand and analyze technical, cognitive, process, and organizational elements and their inter-relationships—within their context-of-use



5 Layers of Analysis

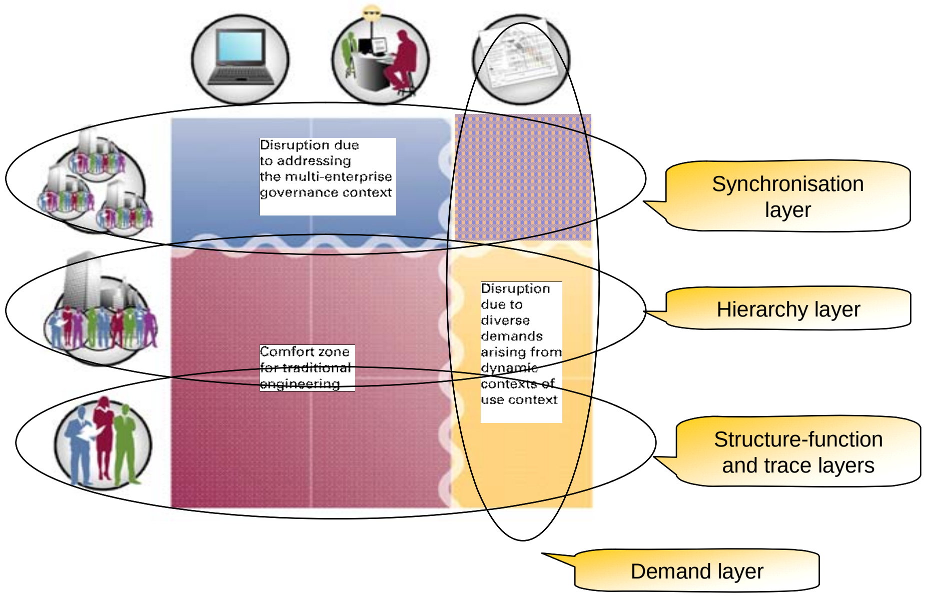
Structure/Function: The physical structure and functioning of resources and capabilities

Trace: The digital processes and systems that interact with the physical processes

Hierarchy: The formal hierarchies under which the uses made of both the physical and the digital are held accountable

Synchronization: The lateral relations of synchronization and orchestration within and between the organizations providing services "on the ground"

Demand: The nature of the contexts-of-use giving rise to demands on the way the operations are organized to deliver effective and timely services



The Outputs

Stratification analyses different levels of interoperability* from the point of view of the demands placed on the system of systems by the environment

- Synchronization (Can the configurations needed interoperate in practice?)
- Orchestration (What are the dynamic load characteristics generated?)
- Customization (Will baseline functionality be met?)

*** Stratification**

6. Effects environment
5. Mission environment
4. Deployed Force

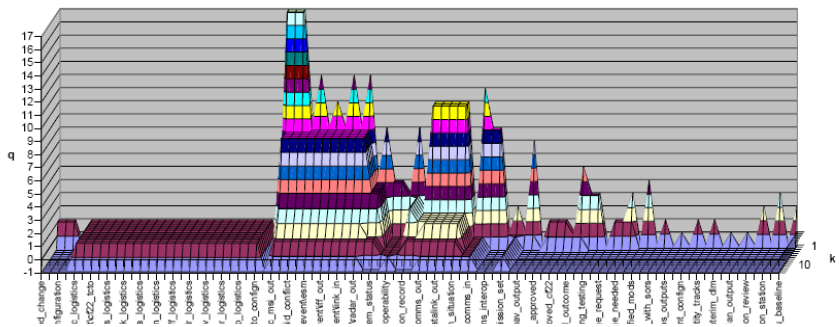
---

3. Operationally ready capabilities
2. Field-able capabilities
1. Equipment and bought-in capabilities

Landscapes represent topological characteristics of the system of systems

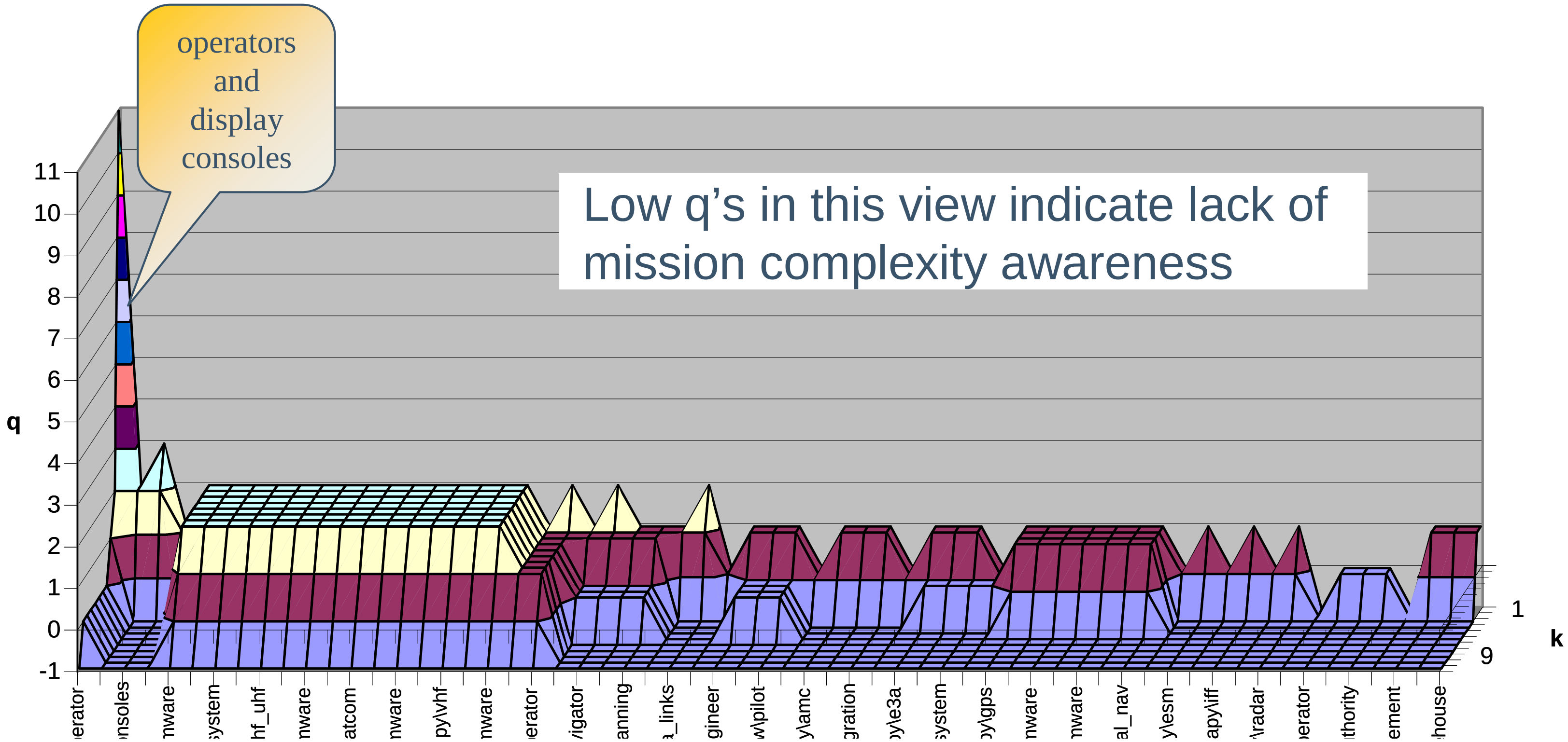
- Interoperability 'hotspots' (peaks)
- Risks (gaps between peaks)

Landscape



Analysis for Synchronization

Shows that the predominant mission awareness integration point is the system operator and the operator's display console



Source: An Examination of a Structural Modeling Risk Probe Technique, Anderson, Boxer & Brownsword (2006), http://www.sei.cmu.edu/publications/documents/06.reports/06sr017.html

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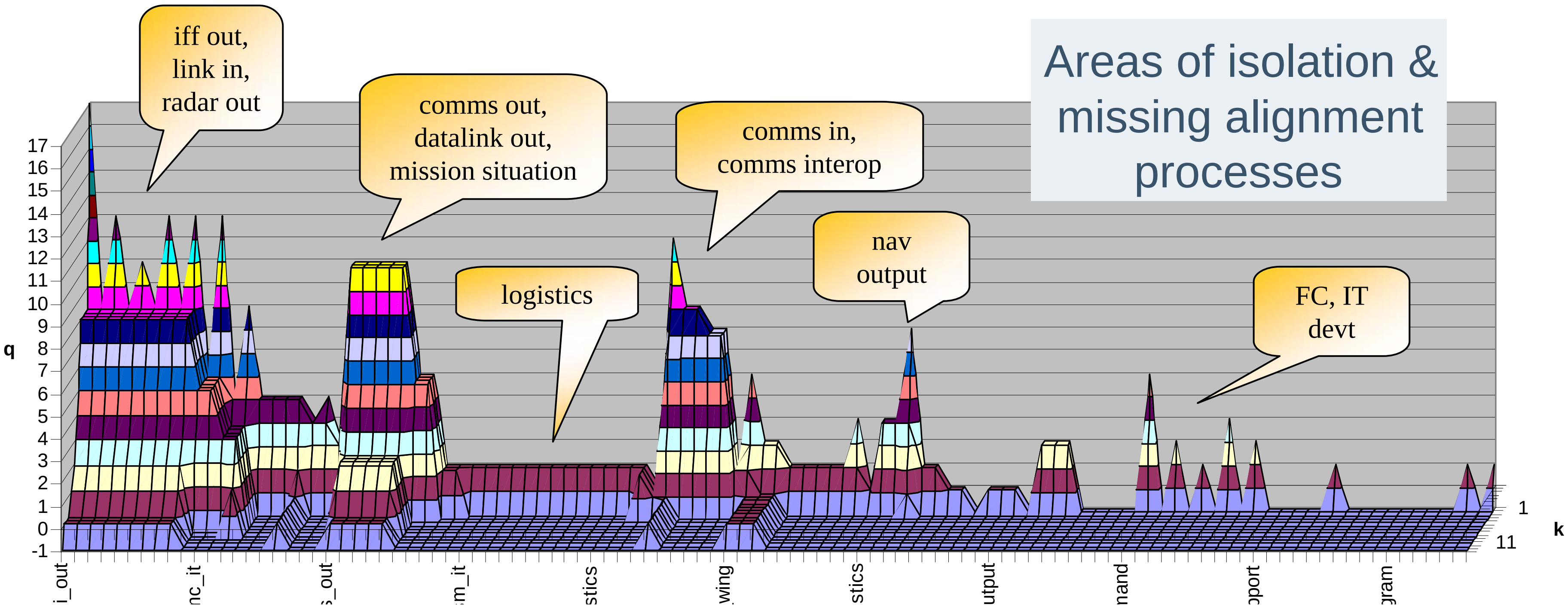
Analysis for Orchestration

Reveals areas of isolation, islands of high connectivity, and broad regions of separation



Source: An Examination of a Structural Modeling Risk Probe Technique, Anderson, Boxer & Brownsword (2006), http://www.sei.cmu.edu/publications/documents/06.reports/06sr017.html

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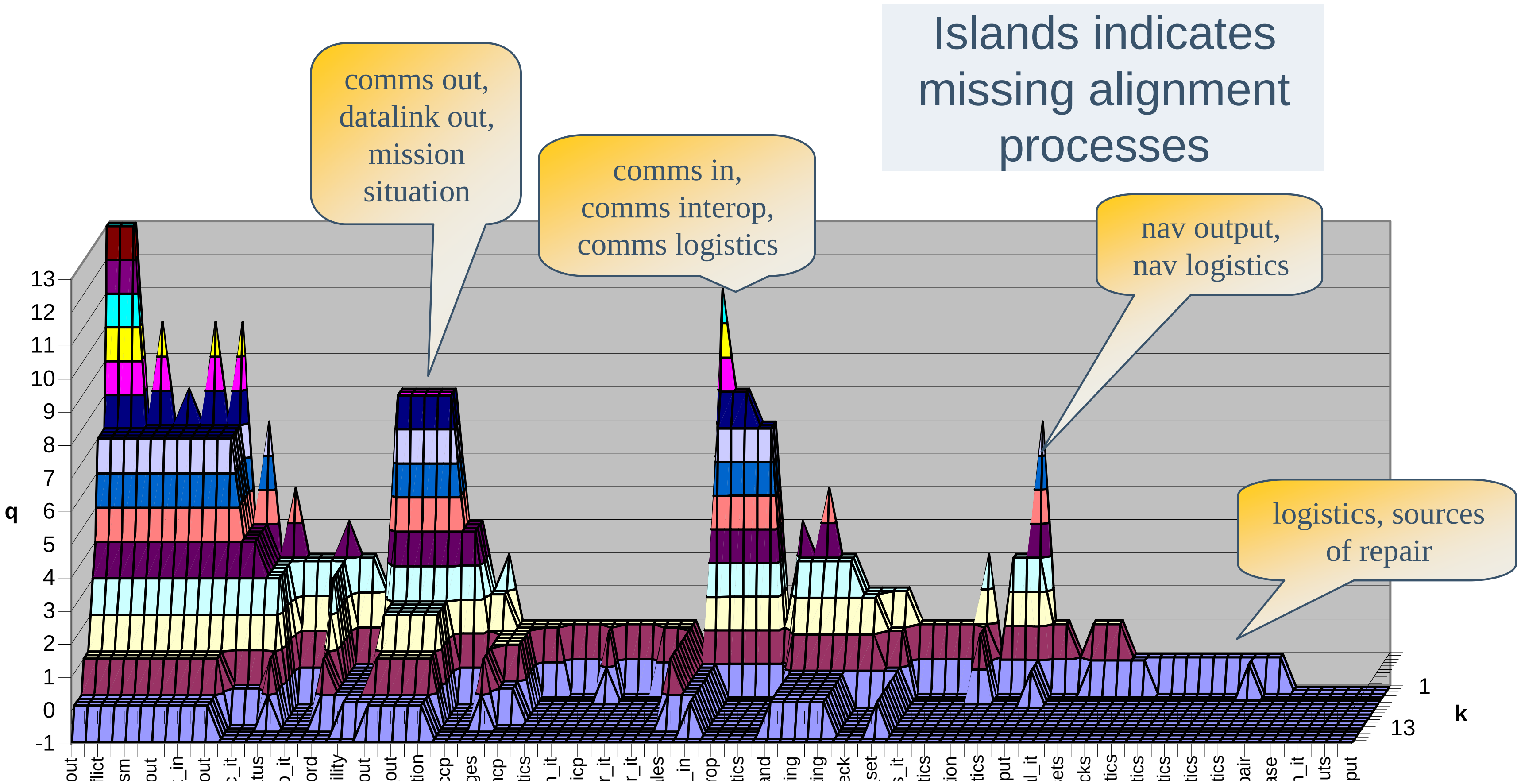
Analysis for Customization



Source: An Examination of a Structural Modeling Risk Probe Technique, Anderson, Boxer & Brownsword (2006), http://www.sei.cmu.edu/publications/documents/06.reports/06sr017.html

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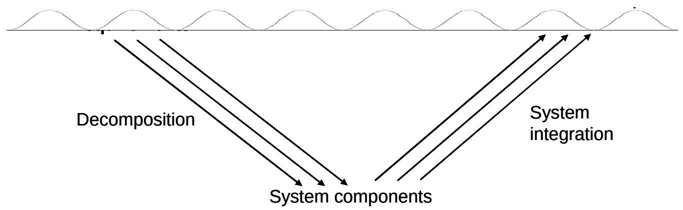
Putting It Together

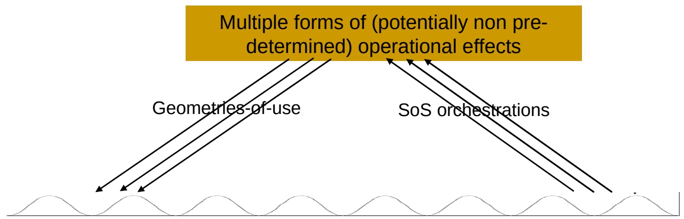
Where were they?

- The organization was driven by an acquisition focus for systems with a pre-defined range of performance requirements.



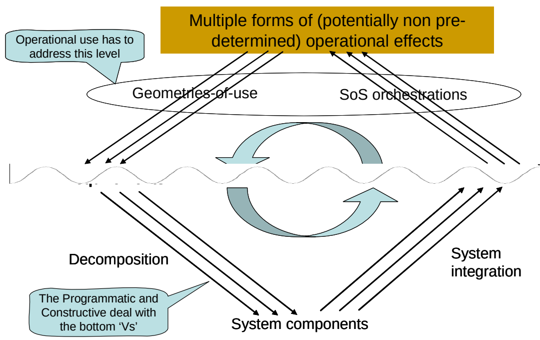
Where did they need to be?

- They needed to relate the current state of operational mission capability to its evolving role through its life.



What were the gaps?

- They had no effective way of managing this cycle as a whole.



Source: Managing the SoS Value Cycle, Philip Boxer (2007)
http://www.asymmetricdesign.com/archives/85

Summary

Systems of systems offer new opportunities and challenges

- Potential for greater range of composite mission capabilities orchestrated across systems of systems.
- Need for the ability to continuously extend and adapt an operational capability through its life as a part of a system of systems

This presents a double challenge—both the institutional alignment and the alignment to new and emerging forms of demand.

We can evaluate and characterize the gaps and risks by examining the forms of interoperability possible within a context.

Providing methods to “work” the double V as an integrated cycle can provide the means of mitigating risks arising from this dynamic (re-) alignment through the life of the military operational capability.

For More Information

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Developmental Test & Evaluation Policy Vectors

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T&E Policy

Developmental Test & Evaluation
OUSD(AT&L)/Systems & Software Engineering

Outline

- Intro to OSD DT&E
- DT&E Mission, Roles and Functions
- DT&E Priorities

Common Threads Through Breached Programs

- **Nine key failures visible in current Nunn-McCurdy breaches:**
  - **Change in doctrine, driving quantity or mission changes**
  - **Requirements problems (unrealistic, not stable, creep, etc.)**
  - **Lack of a robust baseline**
  - **Inadequate SE / T&E, risk management, and or FMECA**
  - **Inadequate staffing / experience / oversight levels**
  - **Poor reliability**
  - **Acquisition reform**
  - **Schedule / cost realism (concurrency, estimation, etc.)**
  - **Contract (warranty, price curves, TSMR, etc.)**

Top 10 Emerging Systemic Issues

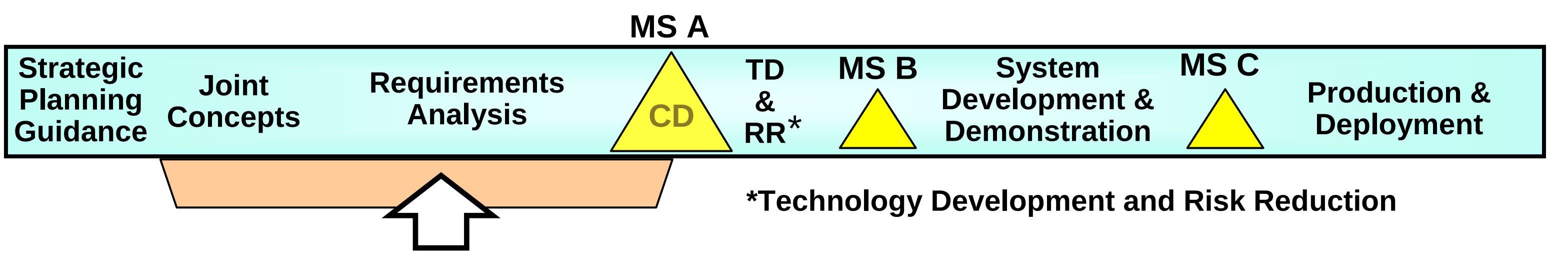
DEVELOPMENTAL T&E

1. Management	• **IPT roles, responsibilities, authority, poor communication** • **Inexperienced staff, lack of technical expertise**
2. Requirements	• **Creep/stability** • **Tangible, measurable, testable**
3. Systems Engineering	• **Lack of a rigorous approach, technical expertise** • **Process compliance**
4. Staffing	• **Inadequate Government program office staff**
5. Reliability	• **Ambitious growth curves, unrealistic requirements** • **Inadequate "test time" for statistical calculations**
6. Acquisition Strategy	• **Competing budget priorities, schedule-driven** • **Contracting issues, poor technical assumptions**
7. Schedule	• **Realism, compression**
8. Test Planning	• **Breadth, depth, resources**
9. Software	• **Architecture, design/development discipline** • **Staffing/skill levels, organizational competency (process)**
10. Maintainability/Logistics	• **Sustainment costs not fully considered (short-sighted)** • **Supportability considerations traded**

Major contributors to poor program performance

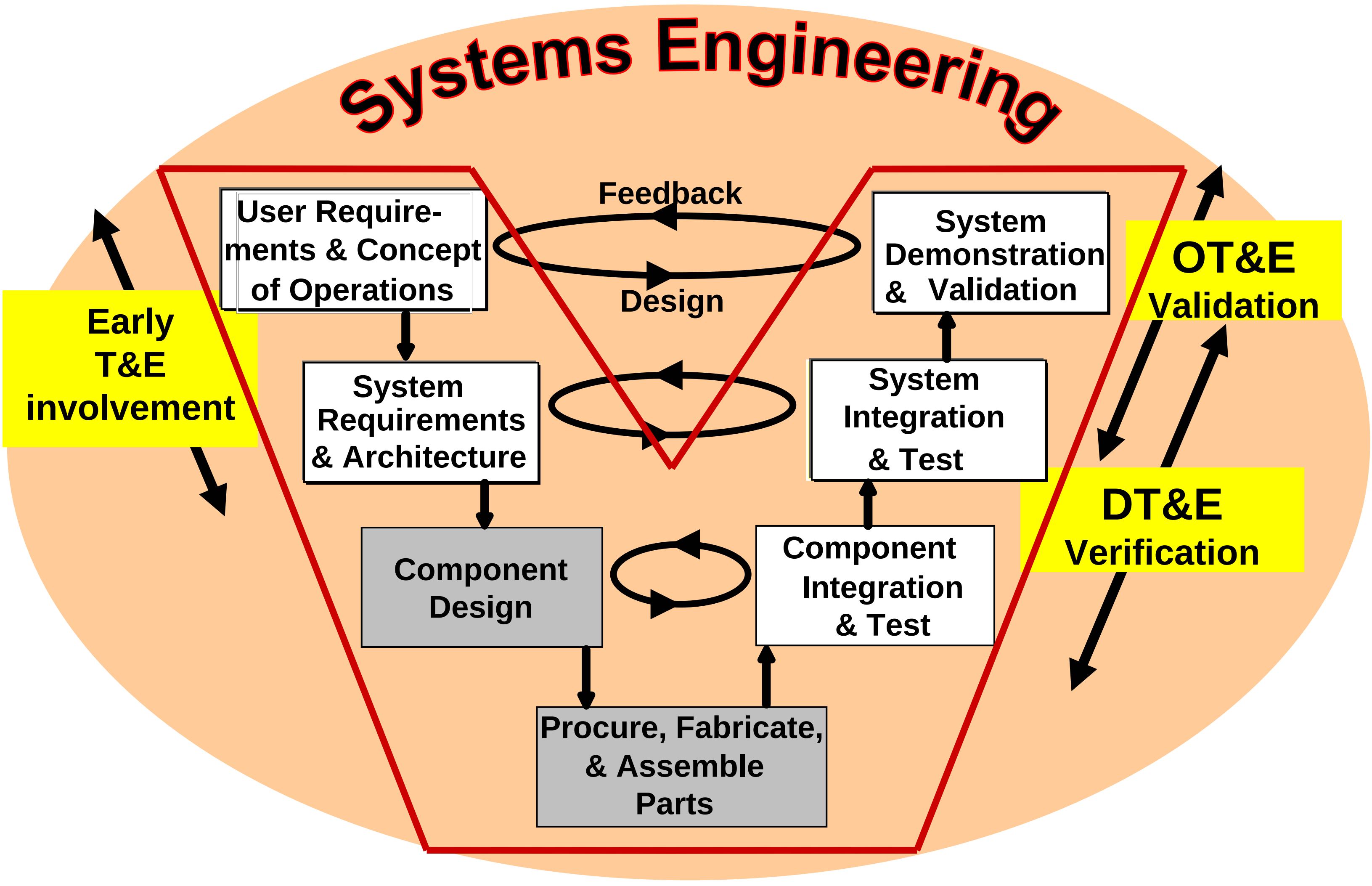
Early Lifecycle Planning

- **Early lifecycle involvement of Systems Engineering to:**
  - Inform evaluation of alternatives with technical insights
  - Ensure solutions balance requirements with technical feasibility
  - Ensure solutions can be validated and verified
  - Use Modeling & Simulation to help refine warfighter concept of operations/system requirements, evaluate design alternatives, and identify potential technology/human interface constraints
- **Appropriate resourcing (personnel/funding) required**
- **Include in requirements, specifications, and contracts**

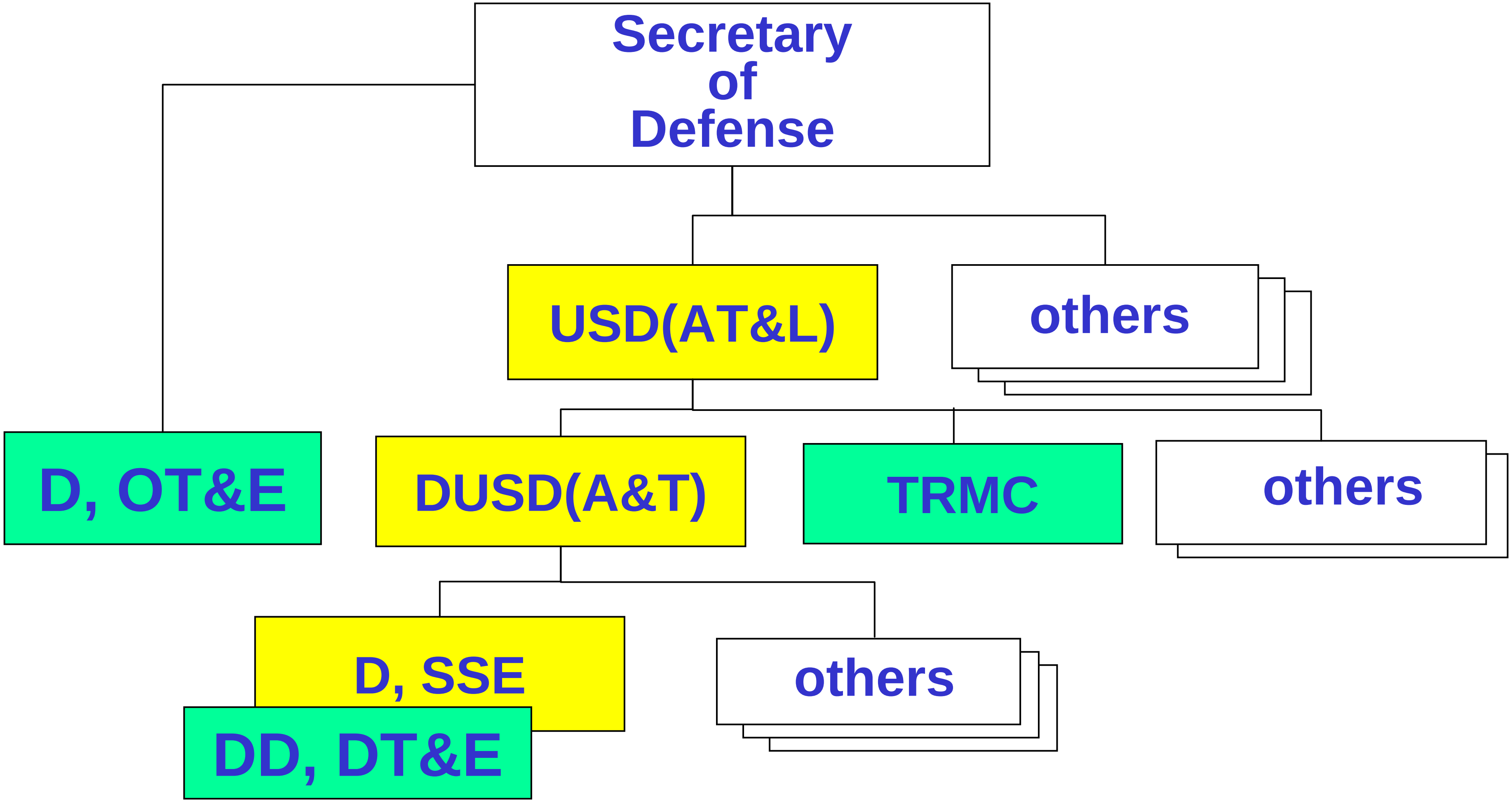


Sustainment must be included up front and early

T&E in Support of Systems Engineering



Where am I in OSD?



Our Mission

- Lead office within the DoD for all matters pertaining to developmental test and evaluation
  - Develops OSD policy concerning DT&E
  - OSD advocate for testers concerning DT&E
  - Responsible for education/training of the T&E acquisition workforce
- Office of primary responsibility for DoD Energy acquisition policy
  - Emerging area of emphasis on new weapon system development
- Lead office for acquisition M&S and System Safety

The Direction We are Heading

- Revitalizing DT&E
  - Department initiative to place more emphasis on government DT&E during system development
- Integrated Test policy
  - Standardizing definitions and execution guidance throughout the Services and OSD
- Testing in a Joint Environment
  - Several ongoing initiatives (JTEM, L-V-C, DMO, etc)

The Need to Revitalize DT&E

- Too many acquisition programs not operationally effective or suitable
  - Several reasons postulated as cause – reduction in governmental DT&E?
- Policy has languished concerning governmental involvement during system development
- DT data typically not relevant to the evaluation of a system's operational readiness
  - Scope is concentrated on more technical parameters
- DT focused on single system development
  - Needs wider emphasis on system of system and/or system employment in a joint context

A New Vector for DT&E

- Support Faster Fielding of Improved Capabilities
- Reduce Risk of Immature Technology in Systems Development
- Revitalize T&E Workforce Education
- Promote Joint T&E in Live-Virtual-Constructive Environments
- Provide Effective Acquisition Policy and Practices for DT&E

Support Faster Fielding of Improved Capabilities

Objective: Develop T&E policy, practices, and procedures to support Departmental efforts in shortening the time to field capabilities

- Issues:
  - Not pass-fail; but based on capabilities and limitations
  - Integrate T&E strategy - CT, DT, OT
  - Incorporate operational context in DT
  - Collect once, and use data often – Integrated Testing
  - Ensure testable requirements are in EoA / CD
  - Ensure T&E requirements are in SOWs and RFPs
  - Ensure T&E documents consistent with and support:
    - Systems Engineering Plan (SEP)
    - Acquisition Strategy (AS)
    - Capability Documents (ICD, CDD, and CPD)

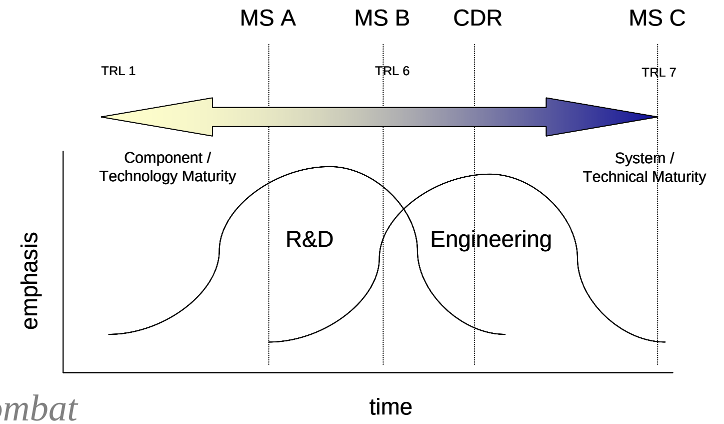
Reduce Risk of Immature Technology in Systems Development

Objective:

- Add Technology Maturity focus into the Systems Engineering and DT&E processes to:
  - Reduce technical, cost, and schedule risk
  - Increase the rigor of SE
  - Plan for alternatives in the event of TM difficulty
  - Verify TRLs during DT&E

Scope

- Leverage existing acquisition review structure
- Use existing DDR&E Technology Readiness Assessment (TRA) methodology

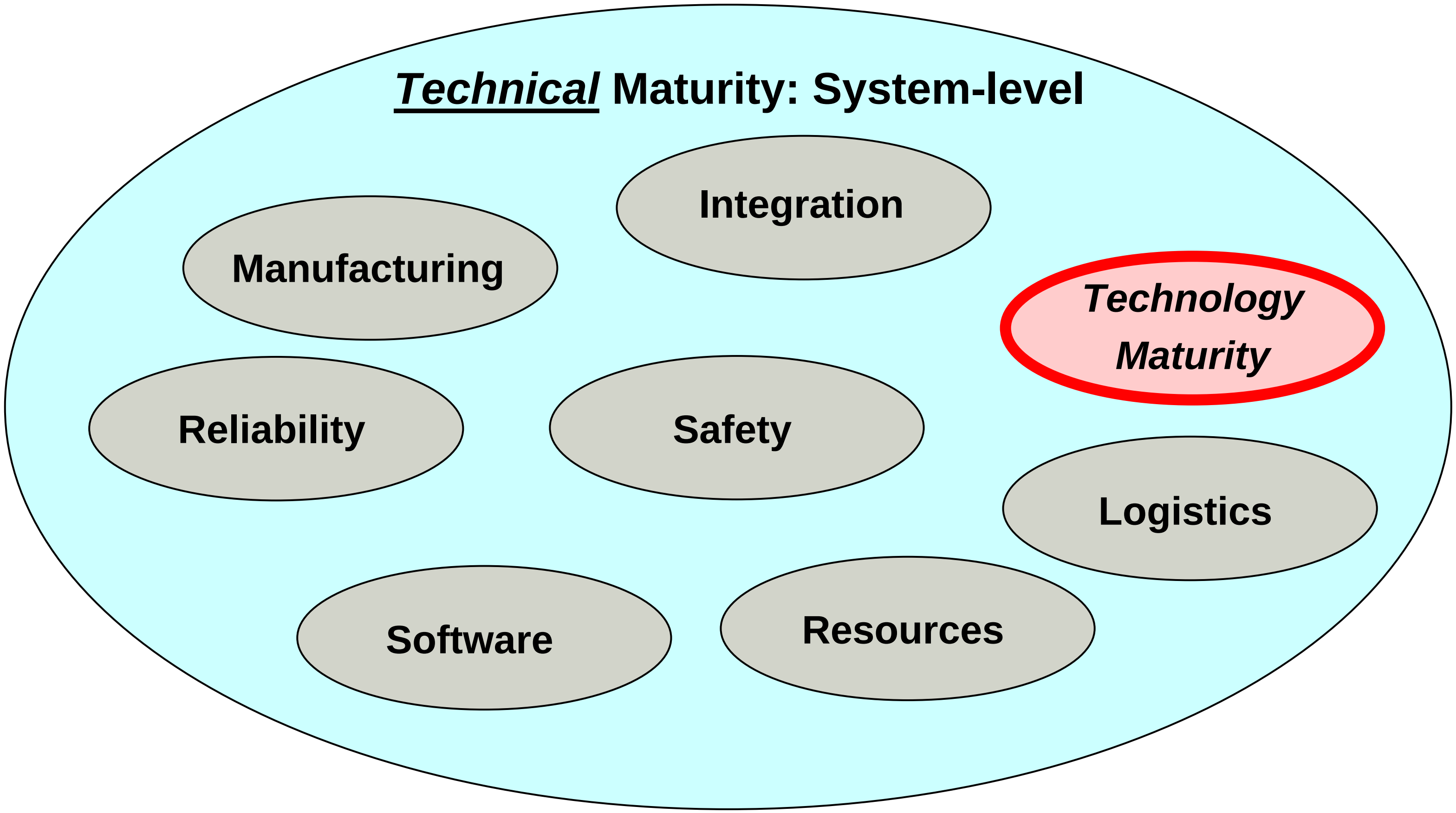


Reduce Risk of Immature Technology in Systems Development

Issues:

- Studies find that immature technology is a primary source of cost and schedule risk
  - GAO -- DAPA
  - QDR -- SSE/AS Program Support Reviews
- "Programs that started development with immature technologies experienced an average acquisition unit cost increase of nearly 21 percent" (GAO-05-301, March 2005)
- FY06, PL 109-163, Section 801 requires USD(AT&L) certification, before Milestone B, that *"the technology in the program has been demonstrated in a relevant environment"*
  - Above wording equates to Technology Readiness Level (TRL) 6

Technology vs. Technical Maturity



Technology Maturity is a component- or subsystem-level issue

Increased TM emphasis in OSD Oversight

- Program Support Review (PSR)
  - ID Critical Technology components/sub-systems?
  - Current TRLs known?
  - ID Mature alternative components/sub-systems?
  - TRL monitoring, Alternative decision date?
- Assessment of Operational Test Readiness (AOTR)
  - TM verification results
  - DT&E performance results
  - IOT&E predictive analysis/M&S

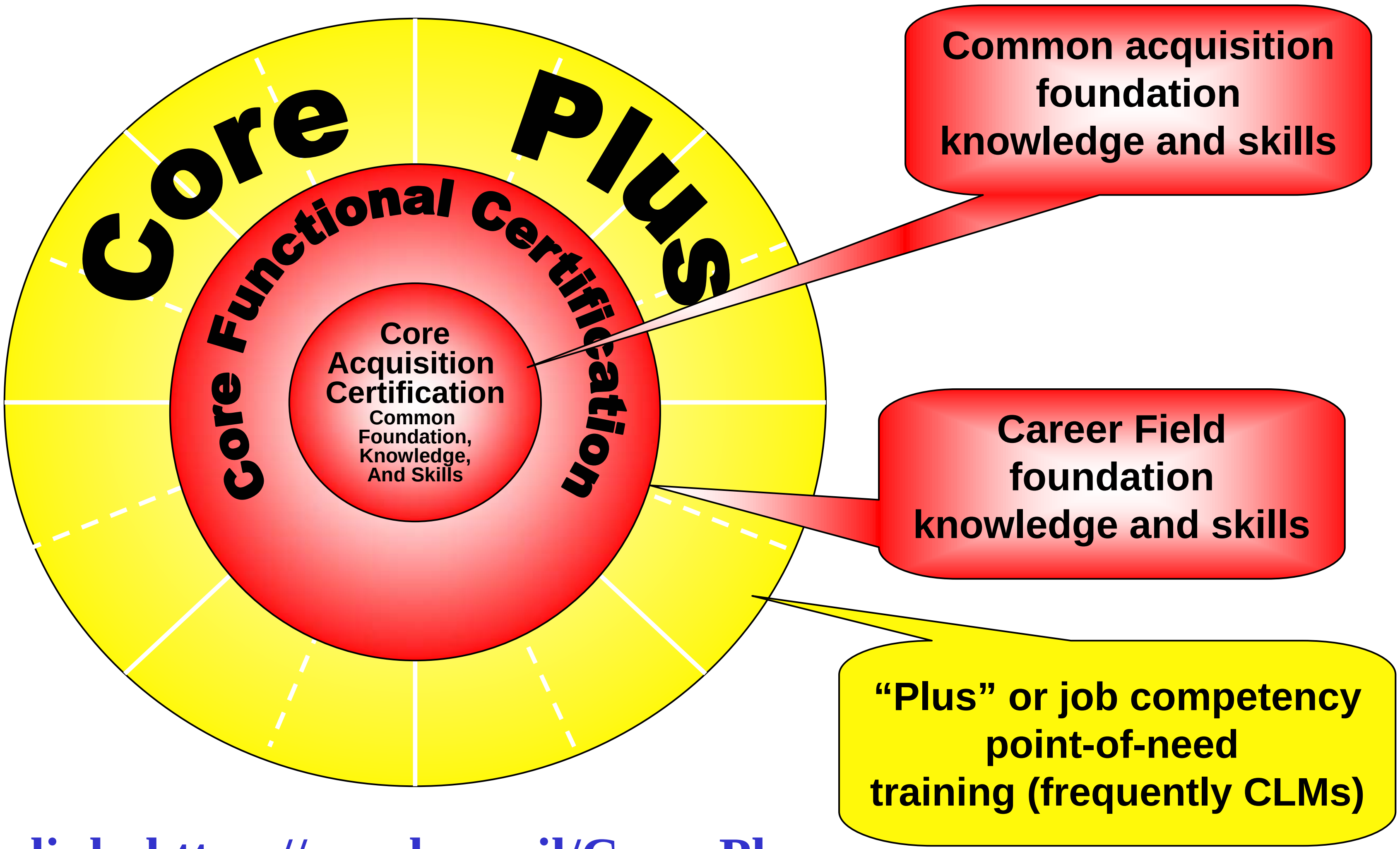
Revitalize T&E Acquisition Workforce Education

Objective: Ensure the T&E acquisition workforce is of sufficient size and adequately trained to perform the T&E tasks required in today's and tomorrow's product/system acquisition process

Issues:

- Continue to ensure current & relevant education, experience, training requirements
- Track new DAU course releases
- Identify the T&E education requirements for SoS and FoS
- Champion the development of new CLMs - such as "M&S for T&E"

DT&E Acquisition Education & Training



•Web-link, https://acc.dau.mil/Core_Plus

Promote Joint T&E in Live-Virtual-Constructive Environments

Objective: Define the role of DT&E in the joint T&E arena and partner with DOT&E, Joint Staff, and Components in defining and developing the necessary polices, practices, and procedures for the conduct of efficient and effective joint T&E

Issues:

- Establishing L-V-C standards
- Defining LVC environment functional requirements
- Identify capabilities & limitations of LVC architectures
- Map capabilities & limitations to requirements
- Compare middleware, business models, standards management, alternatives
- Create roadmap, and socialize it widely
- Define business processes
- Establish a Transition Plan to include: who pays, legacy implementation, etc.

Testing in a Joint Mission Environment

DEVELOPMENTAL T&E

- **Upcoming changes in OSD policy will likely:**
  - ➢ **Require testing in a joint environment for capabilities-based acquisitions**
  - ➢ **Establish governance on the use of the joint mission infrastructure**
  - ➢ **Enable smaller programs to participate and contribute to the joint environment**
  - ➢ **Increase demonstration venues for systems earlier in acquisition cycle**

Provide Effective Acquisition Policy and Practices for DT&E

Objective: Develop and socialize the necessary changes to DT&E policy, practices, and procedures to support the overall AT&L acquisition lifecycle management framework and process

Issues:

- More involvement in the Evaluation of Alternatives and Concept Decision
- Involvement in Capabilities design & SoS T&E
- Develop a format for T&E Strategy (TES)
- Reinforce Integrated T&E approach in TES / TEMP
- Enforce linkage of T&E and SE planning documents
- Incorporate Industry best practices
- Incorporate DT&E standards for:
  - Early involvement (requirements definition in Concept Refinement)
  - Increased operational perspective, operator involvement
  - System sustainment issues
  - Open processes and data availability
  - M&S part of T&E strategy; live test data used to improve M&S

2007 NDIA SE/DT&E Committee Focus

- Three Focus Teams:
  - Earlier contractor and tester involvement
  - Integrated DT/OT and DT operational relevance (combined)
  - Suitability
- Recommend policy changes
  - Input to FY2008 DoD 5000 update

Summary

New Approaches to Acquisition:

- Emphasis on evolutionary acquisition
- Joint capabilities focus
- Net Centricity
- System-of-Systems
- Testing in a joint mission environment

Need a revitalized DT&E capability to be a productive team member

DoD Systemic Root Cause Analysis

Dave Castellano
Deputy Director, Assessments and Support

Laura M. Dwinnell
Systemic Analysis Team Leader

SYSTEMS & SOFTWARE ENGINEERING
Office of the Deputy Under Secretary of Defense
for Acquisition and Technology

23 October 2007

VERSION 1.01

Systems and Software Engineering… What are we all about?

Acquisition Program Excellence through sound systems and software engineering…

- *Help shape portfolio solutions and promote early corporate planning*
- *Promote the application of sound systems and software engineering, developmental test and evaluation, and related technical disciplines across the Department's acquisition community and programs*
- *Raise awareness of the importance of effective systems and software engineering, and drive the state-of-the-practice into program planning and execution*
- *Establish policy, guidance, best practices, education, and training in collaboration with academia, industry, and government communities*
- *Provide technical insight to the leadership to support effective and efficient decision making*

Based on USD(AT&L) 2004 Imperative…

"Provide context within which I can make decisions about individual programs."

Providing Value Added Oversight & Support

- **Tactical, Program and Portfolio Management**

"a"

PEOs & PMs…

- PSR
- AOTR
- SEP
- TEMP
- DAES

Improved Program Execution thru…
Program Unique Recommendations

AS Results Achieved thru

- Open Communication/Debate
- Insight & Information Sharing
- Understanding of Consequences
- Data Driven, Fact-based Information Synthesis

Acquisition Leadership

Improved Acquisition Decision Making thru…

- Greater Program Transparency
- Acquisition Insight

- **Strategic Management**

"A"

DoD Acquisition Community

Improved Acquisition Support to Warfighter

- Systemic Issues & Risks
- Systemic Strengths & Indicators

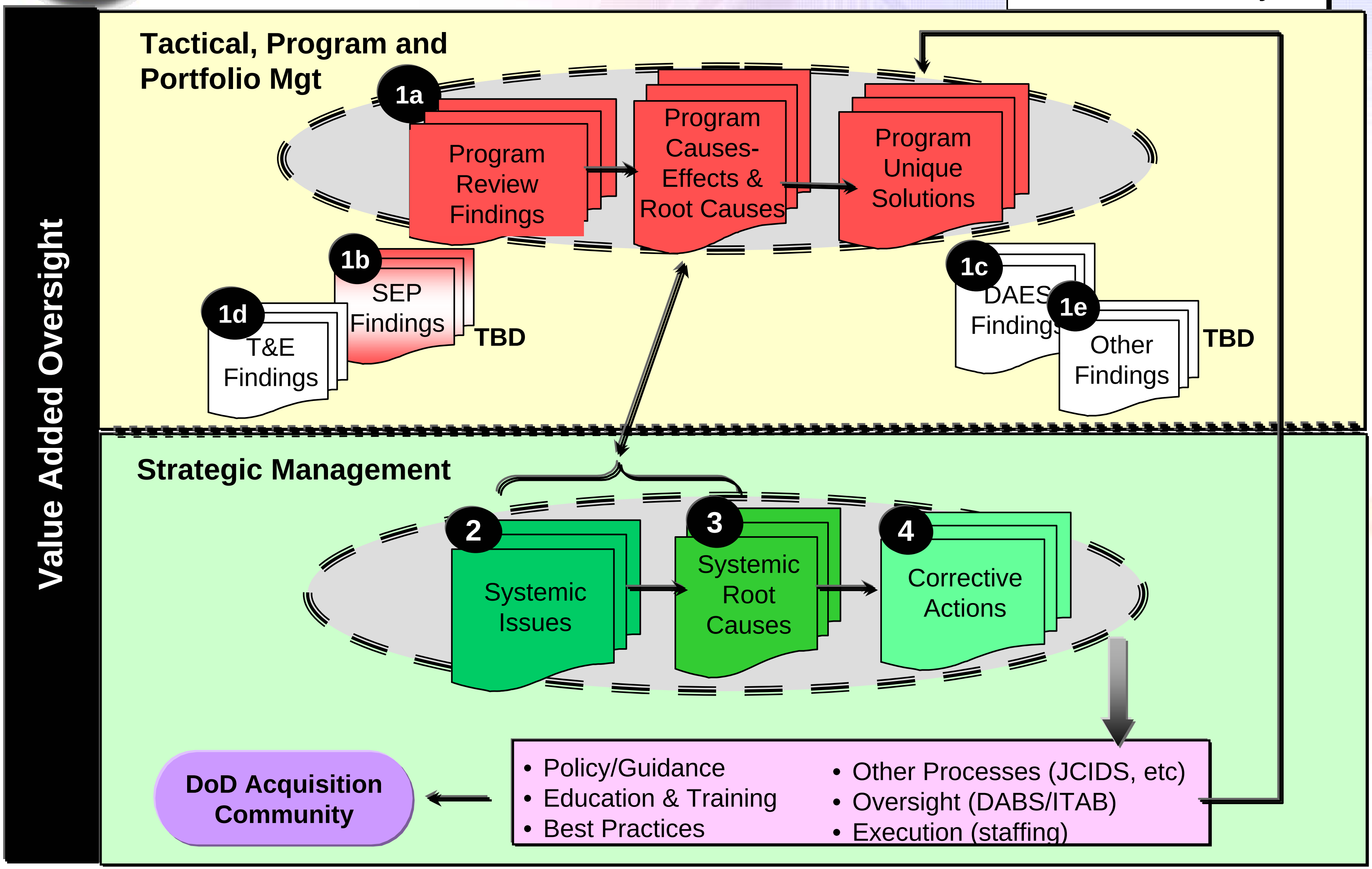
Recommendations

Improved Acquisition Support to Warfighter

- Policy/Guidance
- Education & Training
- Best Practices
- Other Processes (JCIDS, etc)
- Oversight (DABS/ITAB)
- Execution (staffing)

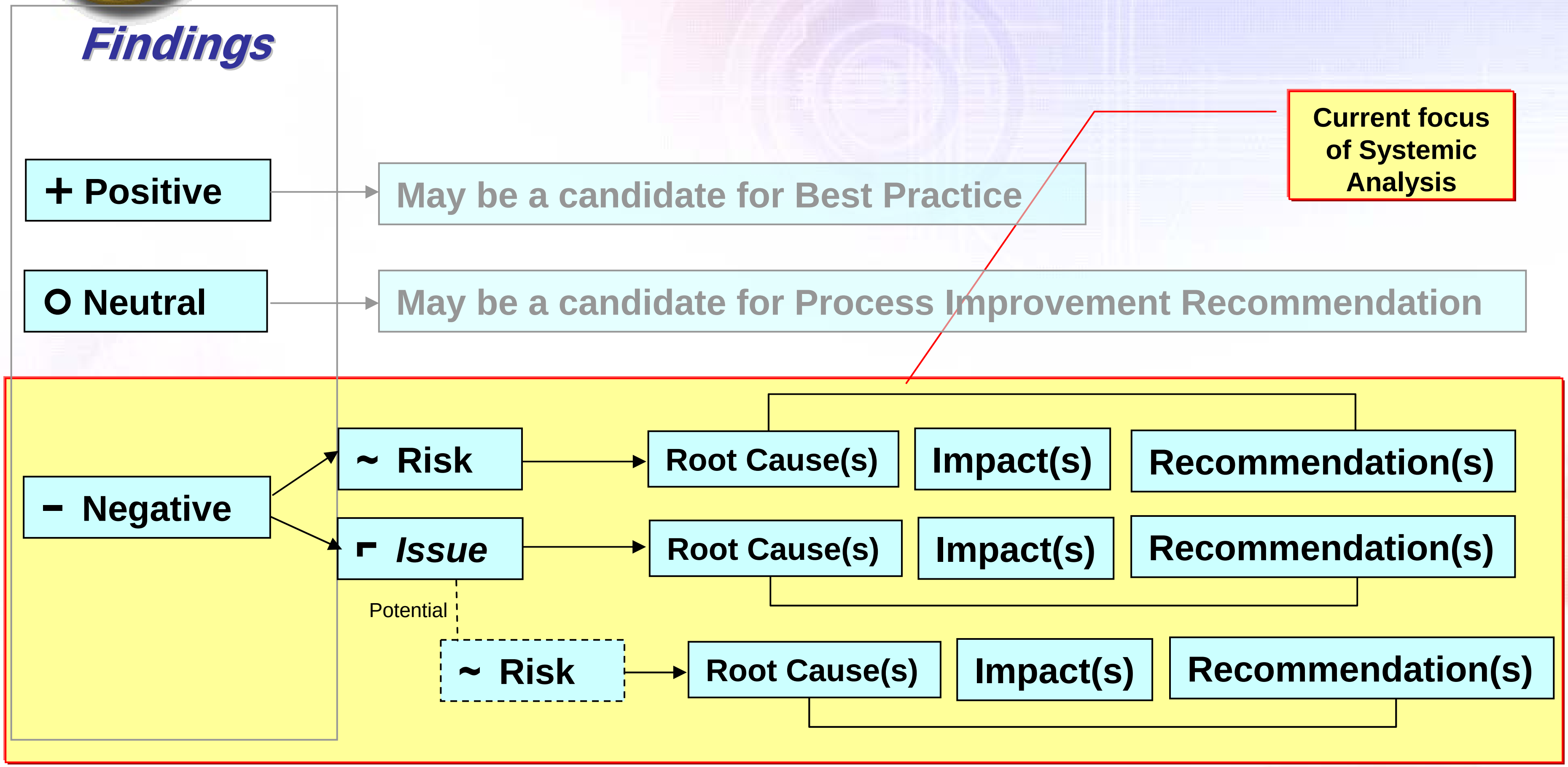
Systemic Analysis: Data Model Rev1

Steps 1a, 1b, 2-4 Underway…



Program Support Review (PSR)
Taxonomy of Classifications

+ Positive
O Neutral
− Negative
⌐ Issue
~ Risk



~3700 Findings from Program Reviews

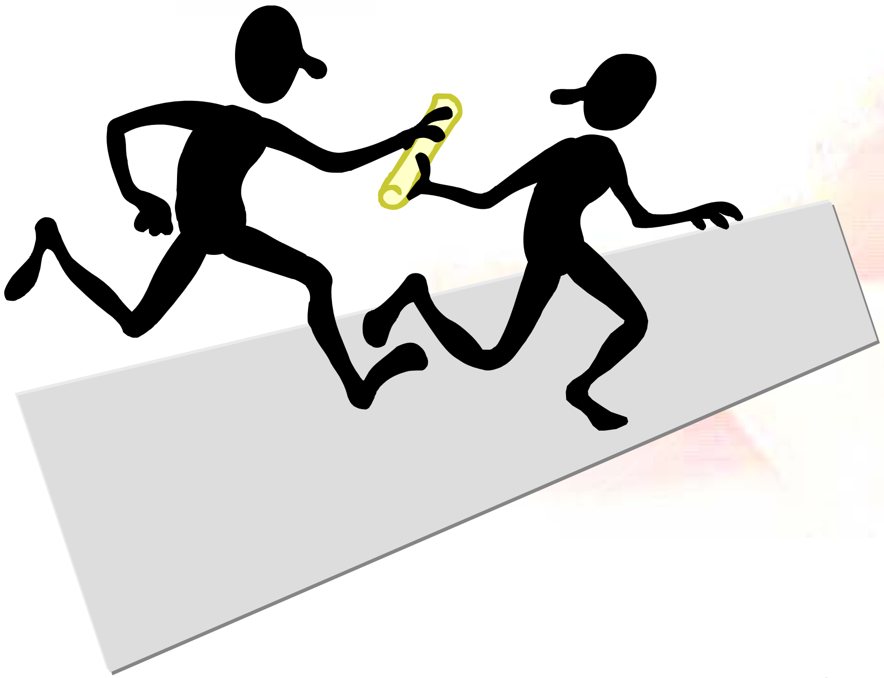
Top 10 Emerging Systemic Issues
(from 52 Program Reviews since Mar 04)

1. Management	• IPT roles, responsibilities, authority, poor communication • Inexperienced staff, lack of technical expertise
2. Requirements	• Creep/stability • Tangible, measurable, testable
3. Systems Engineering	• Lack of a rigorous approach, technical expertise • Process compliance
4. Staffing	• Inadequate Government program office staff
5. Reliability	• Ambitious growth curves, unrealistic requirements • Inadequate “test time” for statistical calculations
6. Acquisition Strategy	• Competing budget priorities, schedule-driven • Contracting issues, poor technical assumptions
7. Schedule	• Realism, compression
8. Test Planning	• Breadth, depth, resources
9. Software	• Architecture, design/development discipline • Staffing/skill levels, organizational competency (process)
10. Maintainability/Logistics	• Sustainment costs not fully considered (short-sighted) • Supportability considerations traded

Major contributors to poor program performance

Observations Since Last Year

- Programs fail because we don't…
  - Start them right
  - Manage them right



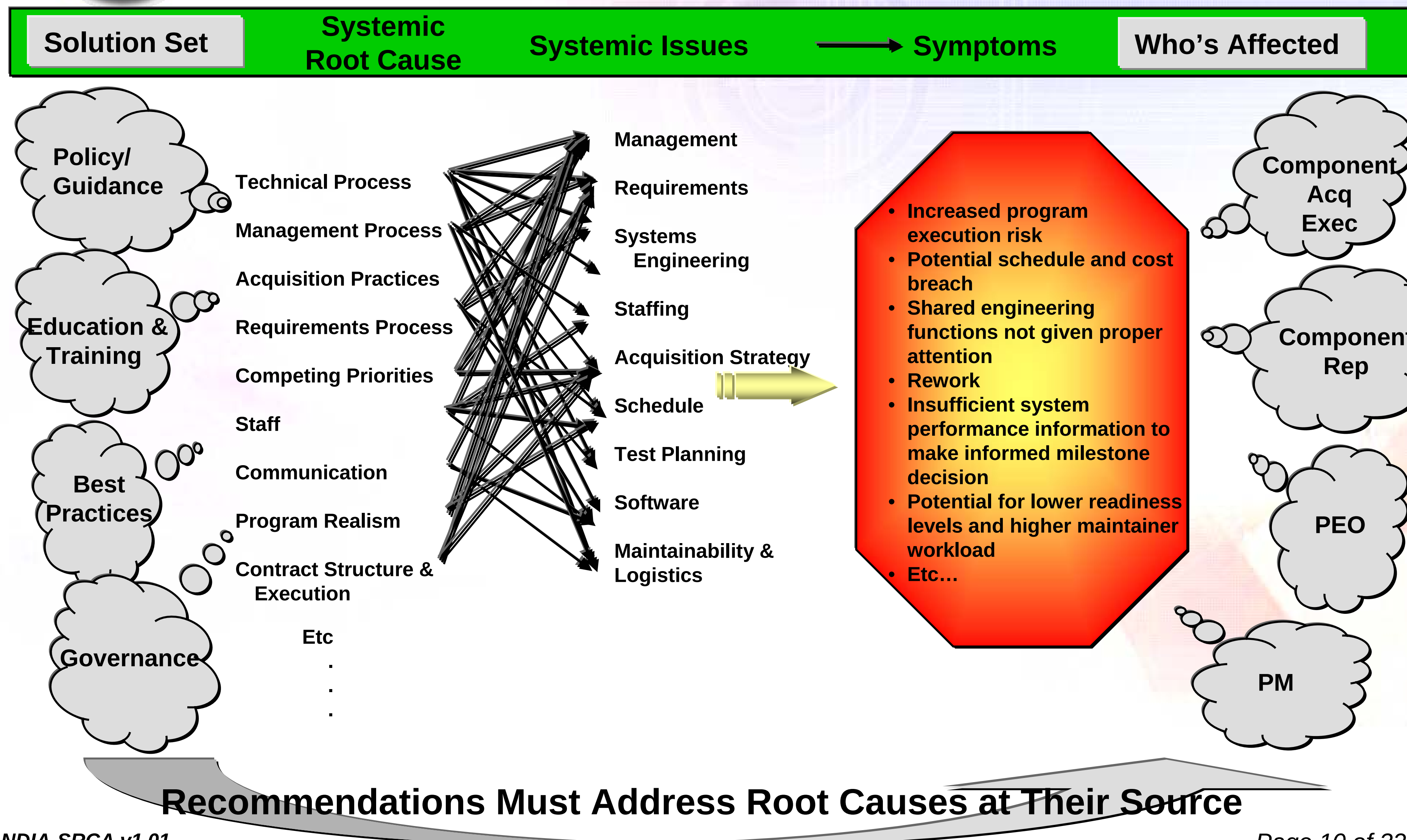
…We Don't Start Them Right

- Requirements creep/stability – not tangible, measurable, testable, defined
- Acquisition strategies based on poor technical assumptions, competing budget prioritities, and unrealistic expectations
- Budget not properly phased
- Lack of rigorous systems engineering approach
- Schedule realism – success oriented, concurrent, poor estimation and/or planning
- Inadequate test planning – breadth, depth, resources
- Optimistic/realistic reliability growth – not a priority during development
- Inadequate software architectures, design/development discipline, and organizational competencies
- Sustainment/life-cycle costs not fully considered (short-sighted)

…We Don't Manage Them Right

- Insufficient trade space – resources, schedule, performance, requirements
- Inadequate IMP, IMS, EVMS
- Insufficient risk management
- Concurrent test program
- Inadequate government PMO staff
- Inexperienced and/or limited staffing
- Poorly defined IPT roles, responsibilities and authority
- Poor communications

Root Cause Effects Model



Systemic Analysis Milestones

Oct 06	Jan 07	Feb – Jul 07	Aug 07	Sep 07
Develop & pilot root cause terms	Conduct SRCA Workshop (Part I)	Apply Root Cause Structure to program findings	Analyze preliminary results	Conduct SRCA Workshop (Part II)

- Categorized root cause textual descriptions
- Terminology developed by small team, limited
- Pilot effort proved that terms lacked proper structure and definition

- Pilot RCT on program reviews: past effort and go-forward
- Definitions enhanced, terminology revised
- Analysis of trends and applicability;

- Redefined Root Cause Type: 3 Tier
- Terminology developed by workshop participants representing DoD and Industry
- RCT structure informally tested on 4 programs from different domain areas

- Validate pilot on root cause method/structure
- Formulate systemic root cause recommendations
- Feedback on SA model and root cause methodology

<u>Coming Up:</u>

Oct 07: Present results to SE community (NDIA-SE Conference)
Nov07: Present results to acquisition community (PEO SYSCOM)
Dec 07: Formalize and standardize methodology
Mar 08: Incorporate other data sources (SEP, Triage, etc)

- Expand analysis to complete data set
- Establish NDIA Working Group on SRCA

Root Cause Types
Recap of Part I Results

- Root Cause Types needed to categorize and discuss root causes
- ***Root Cause Type*** structure defined
  - **Tier 1: Root Cause**
    - » Textual description; documented by PSR team
    - » Perceived program root cause
  - **Tier 2: Systemic Root Cause**
    - » From pre-defined list; assigned by PSR team
    - » Can be "A" or "a". *Conditions that are outside the PMO below the Defense/Service Acquisition Executive level. This would include lateral activities, such as Service staff functions (OPNAV, Air Staff, etc.) and the system commands.*
  - **Tier 3: Core Root Cause**
    - » From pre-defined list; assigned by PSR team
    - » At the "A" level. *Something at the DAE level (3 Star level and above) – Issues resolved through DAE coordination with Congress, DoD, Services, Industry, etc,*

Pilot Underway

Root Cause Analysis is Crux of Systemic Solutions

Root Cause Type Structure

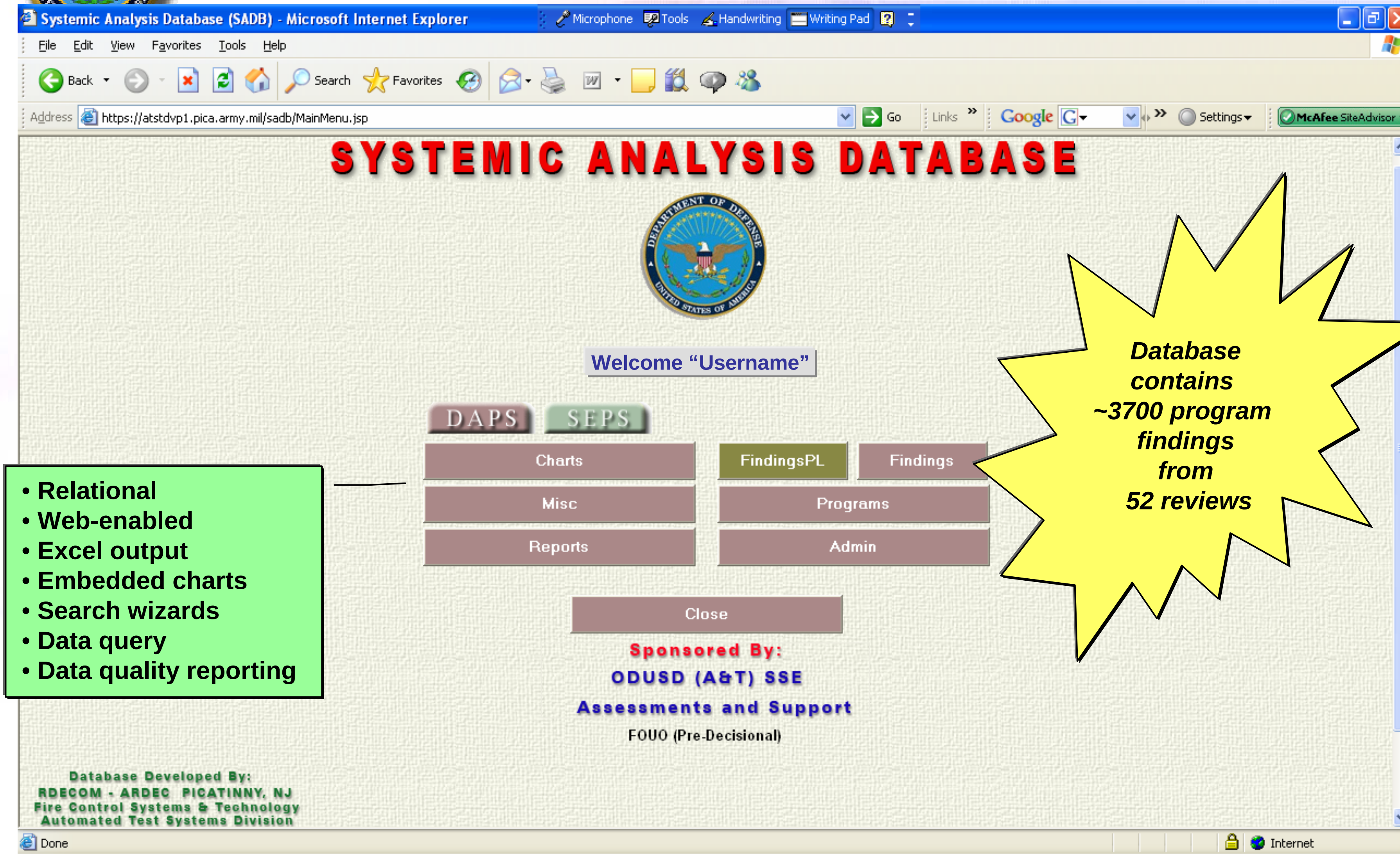
- **Systemic Root Cause (Tier 2)**

1. Ineffective communication
2. Competing priorities
3. CONOPs change
4. Definition of enterprise
5. Engagement of supply base in SE process
6. Expectations not defined
7. Inadequate baseline management
8. Inadequate contract structure and execution
9. Inadequate cost metrics e.g. EVMS
10. Lack of accountability
11. Lack of capital investment
12. Lack of enterprise wide perspective
13. Lack of appropriate staff
14. Lack of trade space/constraints
15. Lack of trust and willingness to share information
16. Obfuscating bad news
17. Ineffective organization
18. Poorly defined roles/responsibilities
19. Process - Management
20. Process - Production
21. Process - Requirements
22. Process - Technical
23. Program realism
24. Responsibility w/o authority
25. Poor Acquisition Practices

- **Core Root Cause (Tier 3)**

1. Acq Reform: Loss of govt. capital investment
2. Acq Reform: Loss of MS A requirement
3. Acq Reform: Transferred Authority
4. Enabling infrastructure
5. Budget POM process (PBBE)
6. Culture
7. Rotations / continuity
8. Inadequate JCIDS process
9. Pool of clearable skilled people
10. External influences
11. Poor business practices

SADB Features



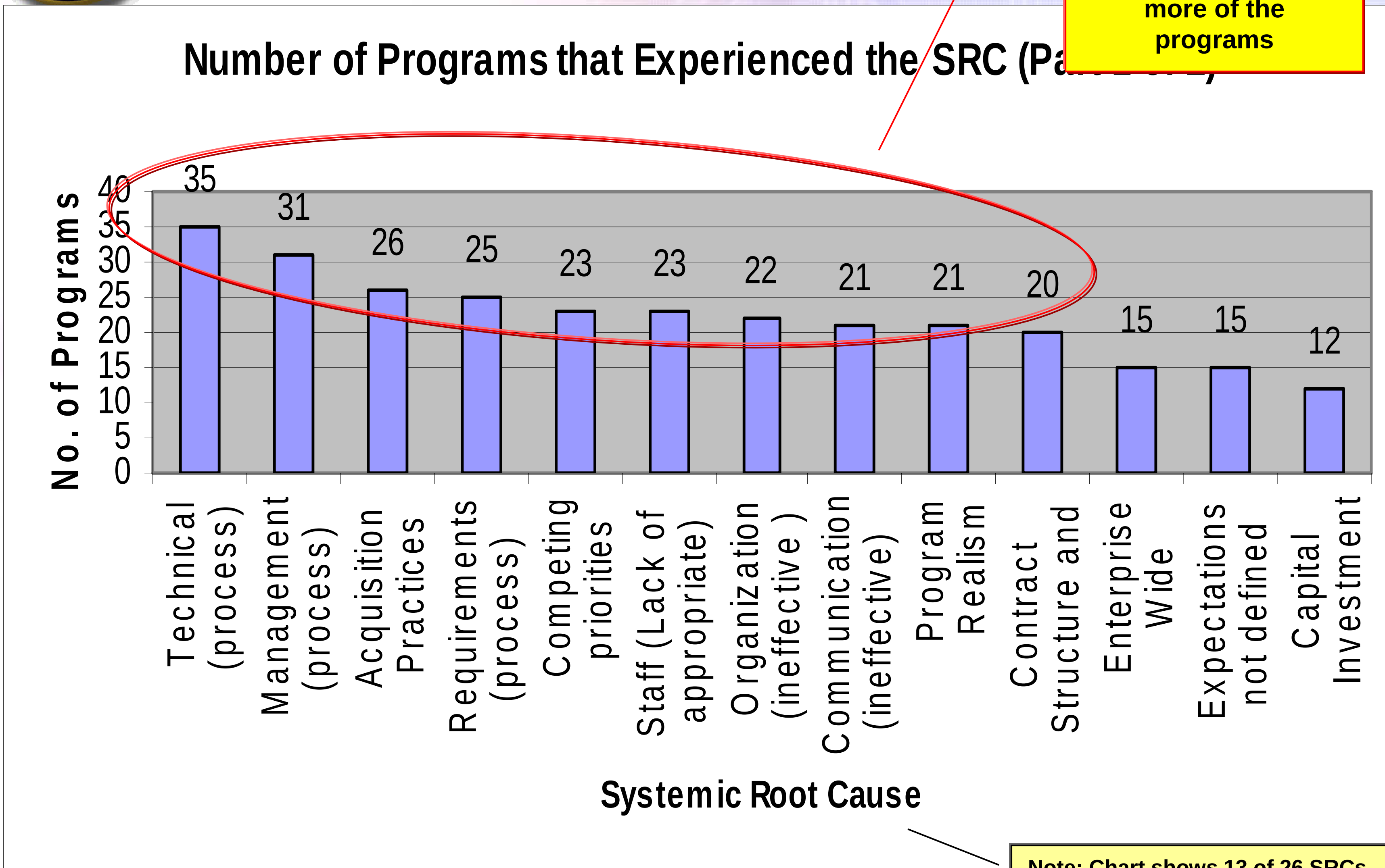
- Relational
- Web-enabled
- Excel output
- Embedded charts
- Search wizards
- Data query
- Data quality reporting

Database contains ~3700 program findings from 52 reviews

- Analysis performed on 44 program reviews
- SRCA applied to *negative* findings: ~ 48% of total set, ~1500 findings
- Trends shown by:
  - (1) Systemic Root Cause (SRC)
  - (2) DAPS areas related to leading SRC
  - (3) Core Root Cause (CRC)
  - (4) SRCs as related to:
    - » CRC = Poor Business Practice
    - » CRC = Culture

See Next 5 Slides for Results…

Categorization by Systemic Root Cause



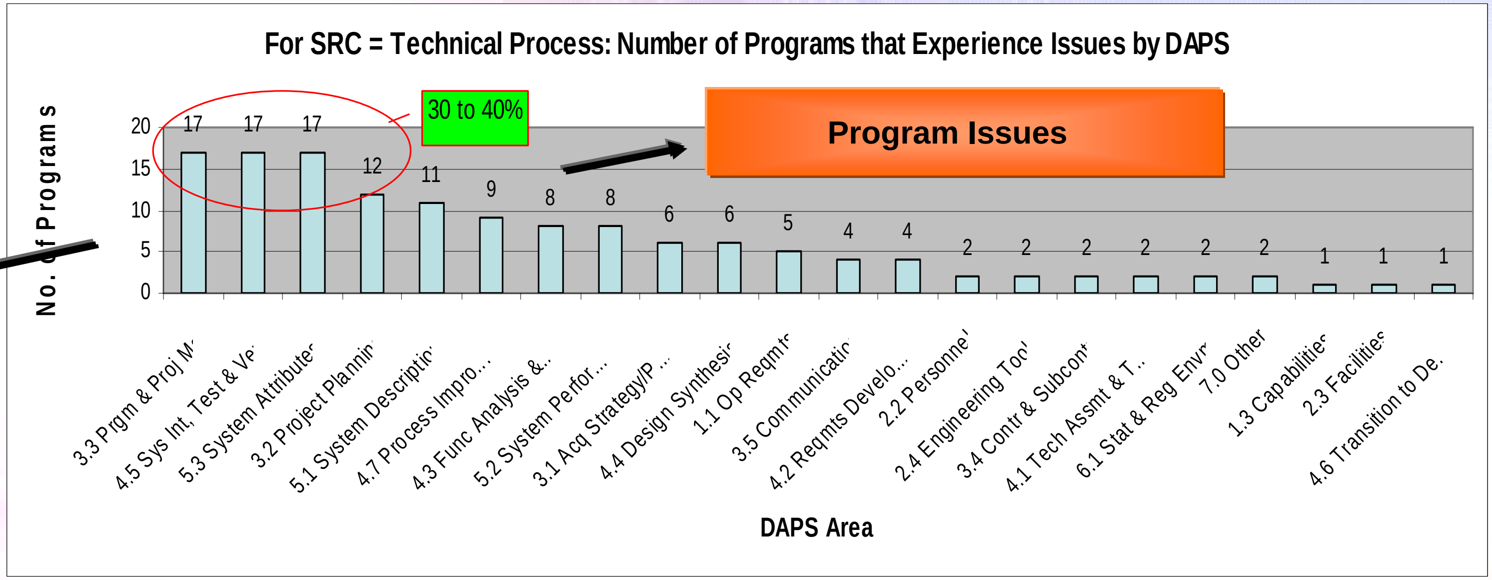
•Occurred on 50% or more of the programs

Note: Chart shows 13 of 26 SRCs

Systemic Root Cause: Technical Process

Systemic Root Cause

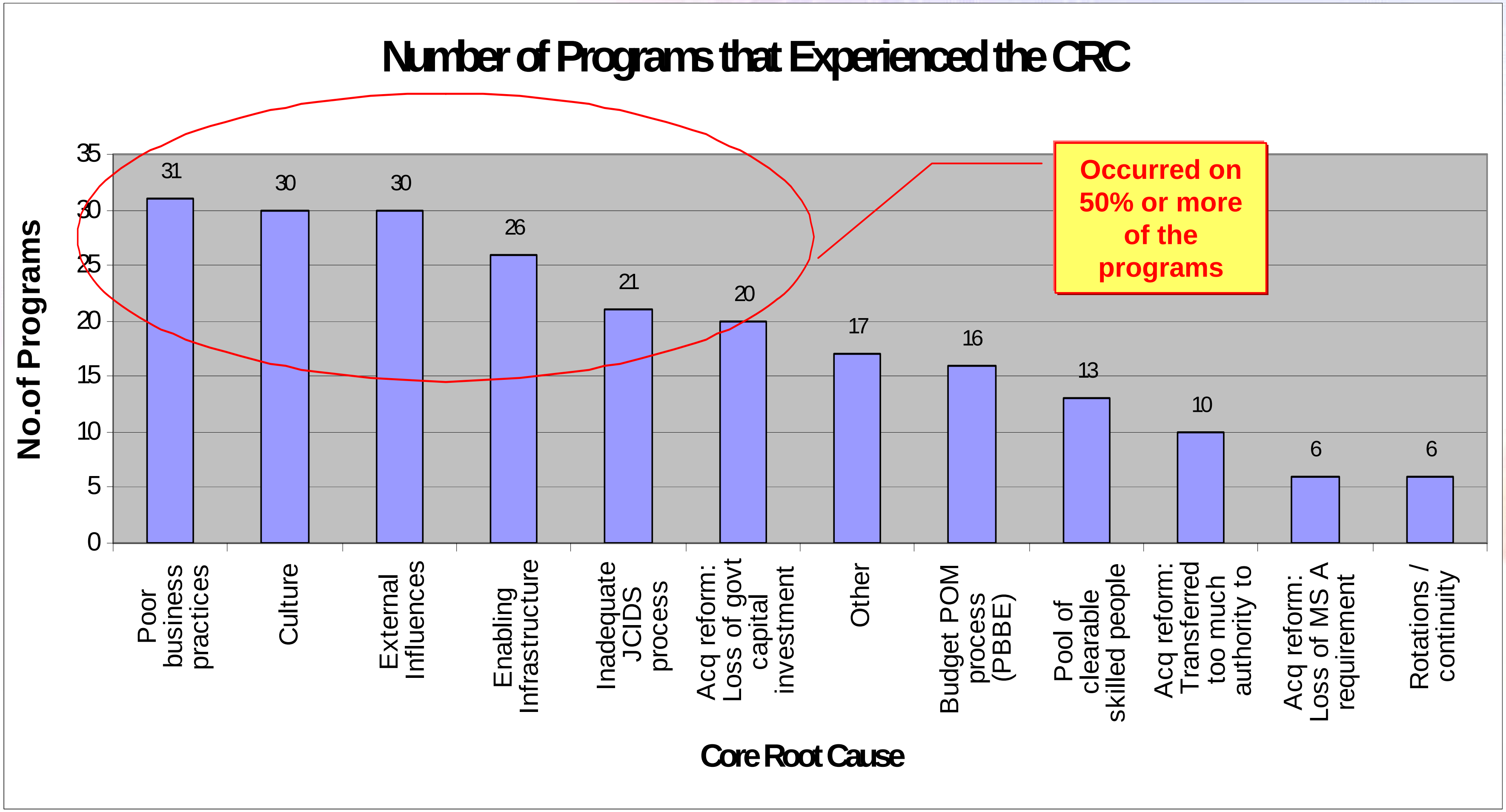
Technical Process



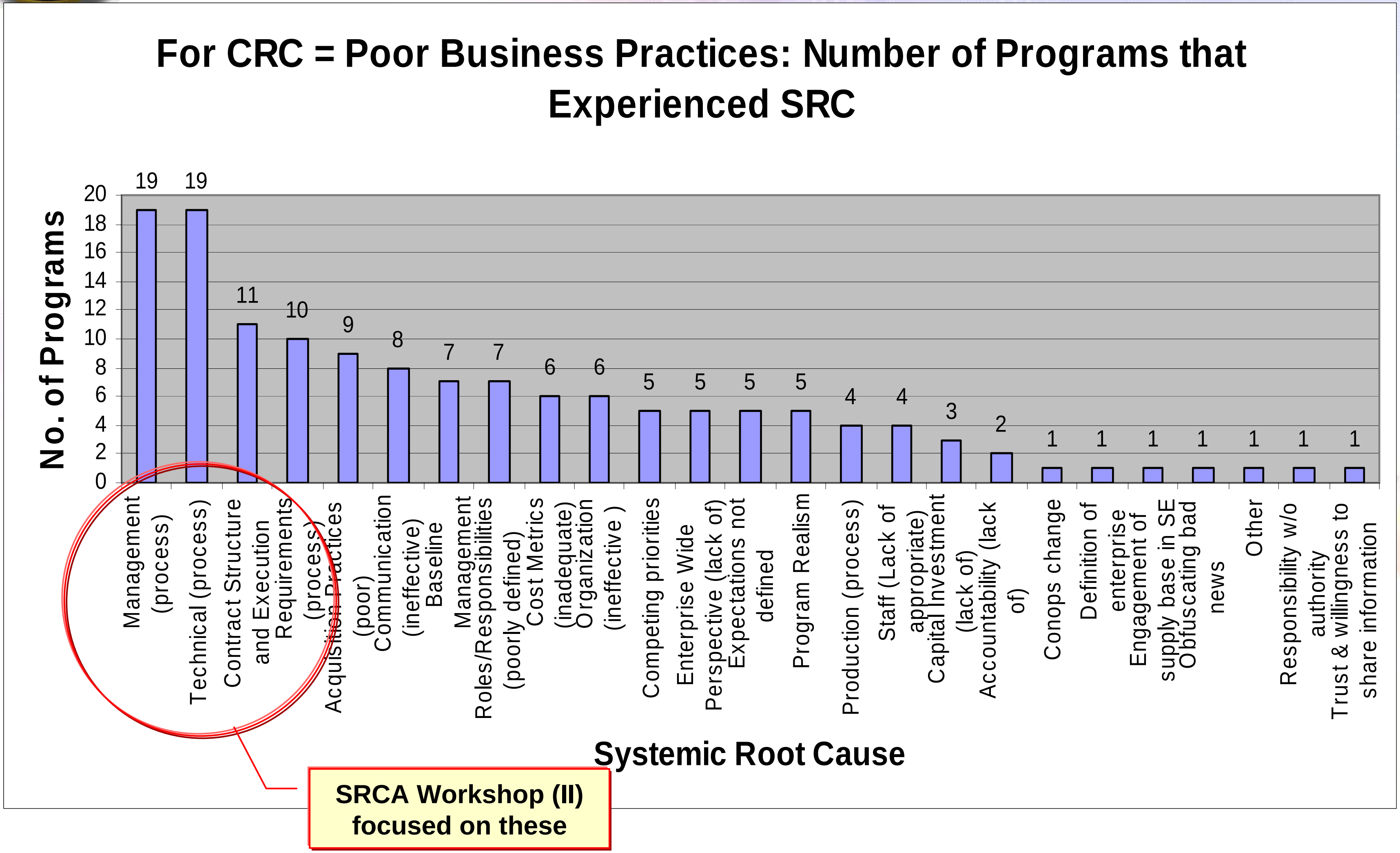
Root Cause Themes

- **Aggressive, success-oriented, highly concurrent test schedule**
- **Reliability not progressing as planned or has failed to achieve requirements**
- **Software reuse was significantly less than planned or expected**
- **Testing and verification approach are inadequate**
- **Program has inadequate systems engineering process**

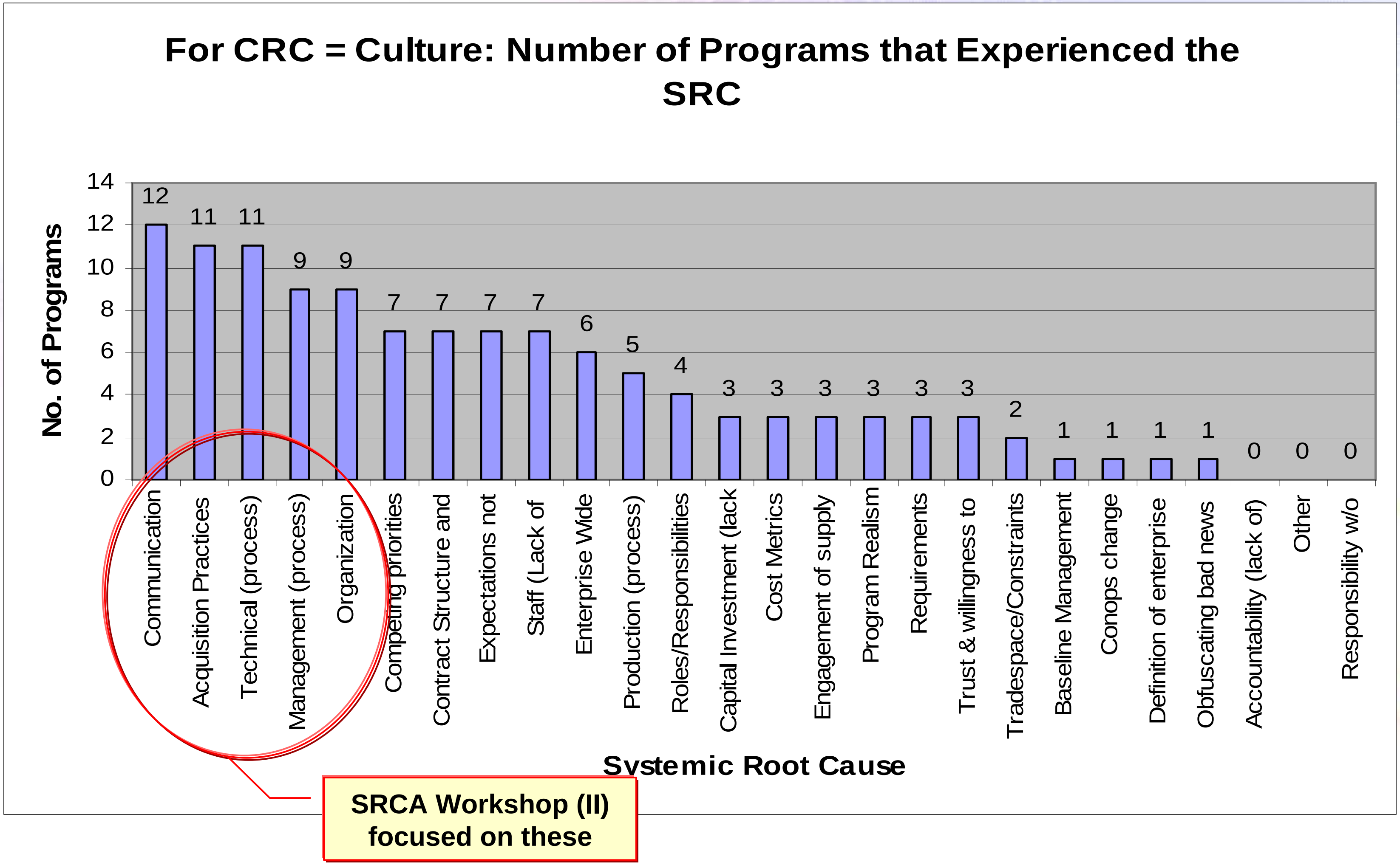
Categorization by Core Root Cause



Relationship between CRC and SRC



Relationship between CRC and SRC

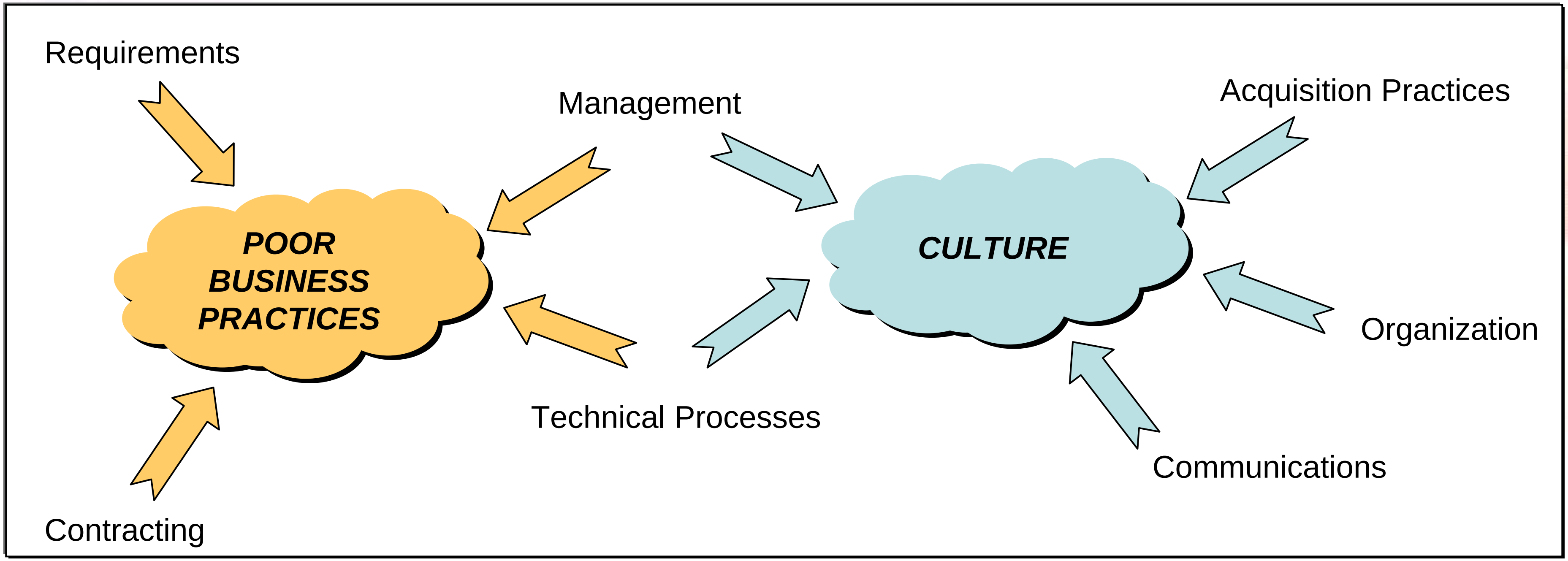


SRCA Workshop Participants
(Part II) 25-26 Sep 07

- Approximately 33 participants representing government and industry
- Non-OSD participants included…
  - Government
    - » Col Horejsi, US Air Force (PEO)
    - » Mr. George Mooney, USAF CSE
    - » Ms. Kathy Lundeen, DCMA
    - » Mr. John Snoderly, DAU
  - Industry
    - » Mr. Bob Rassa, NDIA/Raytheon
    - » Mr. Brian Wells, Raytheon
    - » Mr. Rick Neupert & Mr. Jamie Burgess, Boeing
    - » Mr. Stephen Henry, Northrop Grumman
    - » Mr. Per Kroll, IBM
    - » Mr. Paul Robitaille, Lockheed Martin
    - » Dr. Dinesh Verma, Stevens Institute of Technology
    - » Mr. Dan Ingold, University of Southern California

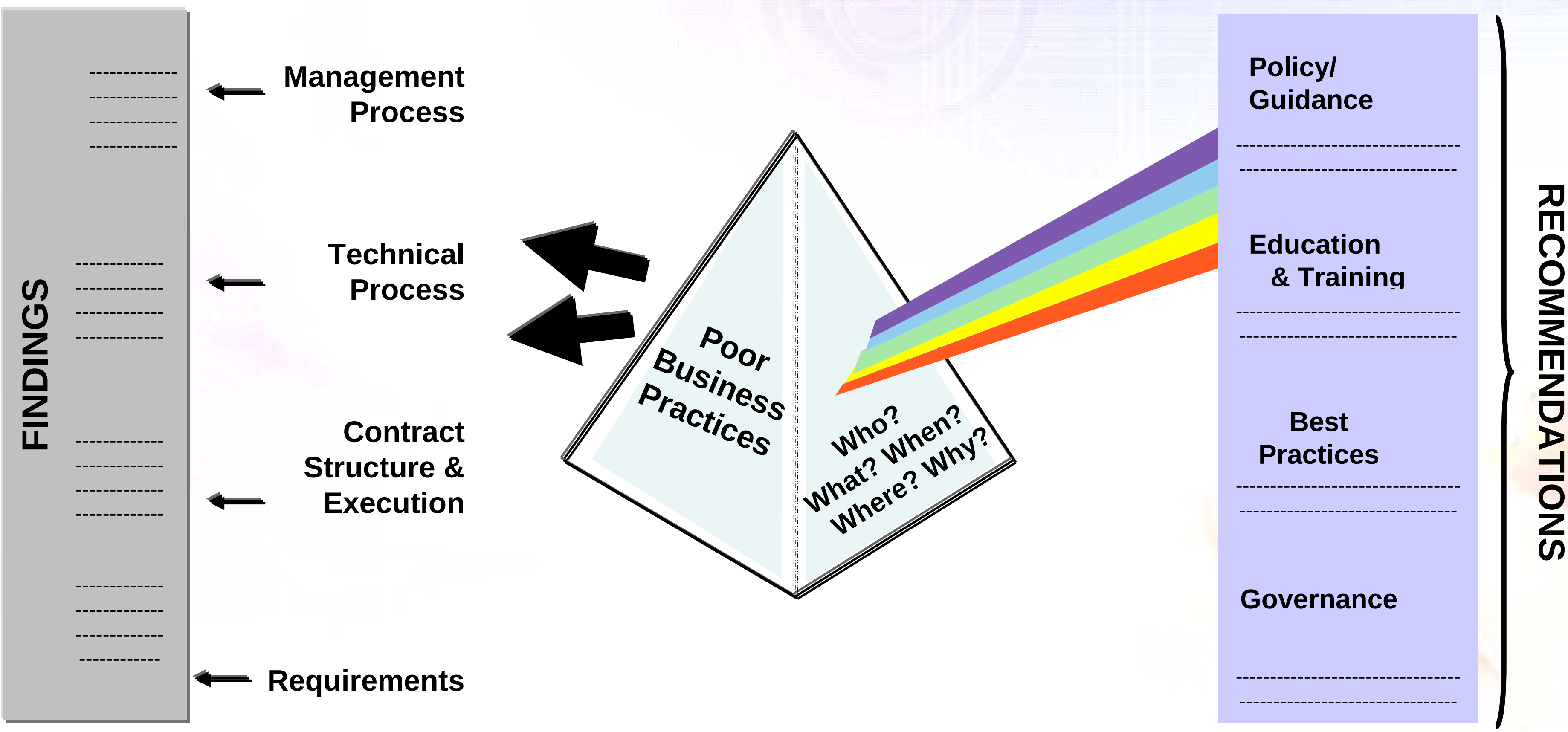
SRCA Workshop (Part II) Objective

- Primary SRCA Workshop II objective:
  - *Formulate systemic root cause recommendations*
- Participants focused on manageable subset of analysis results
  - 2 CRC areas and their top 4-5 SRCs



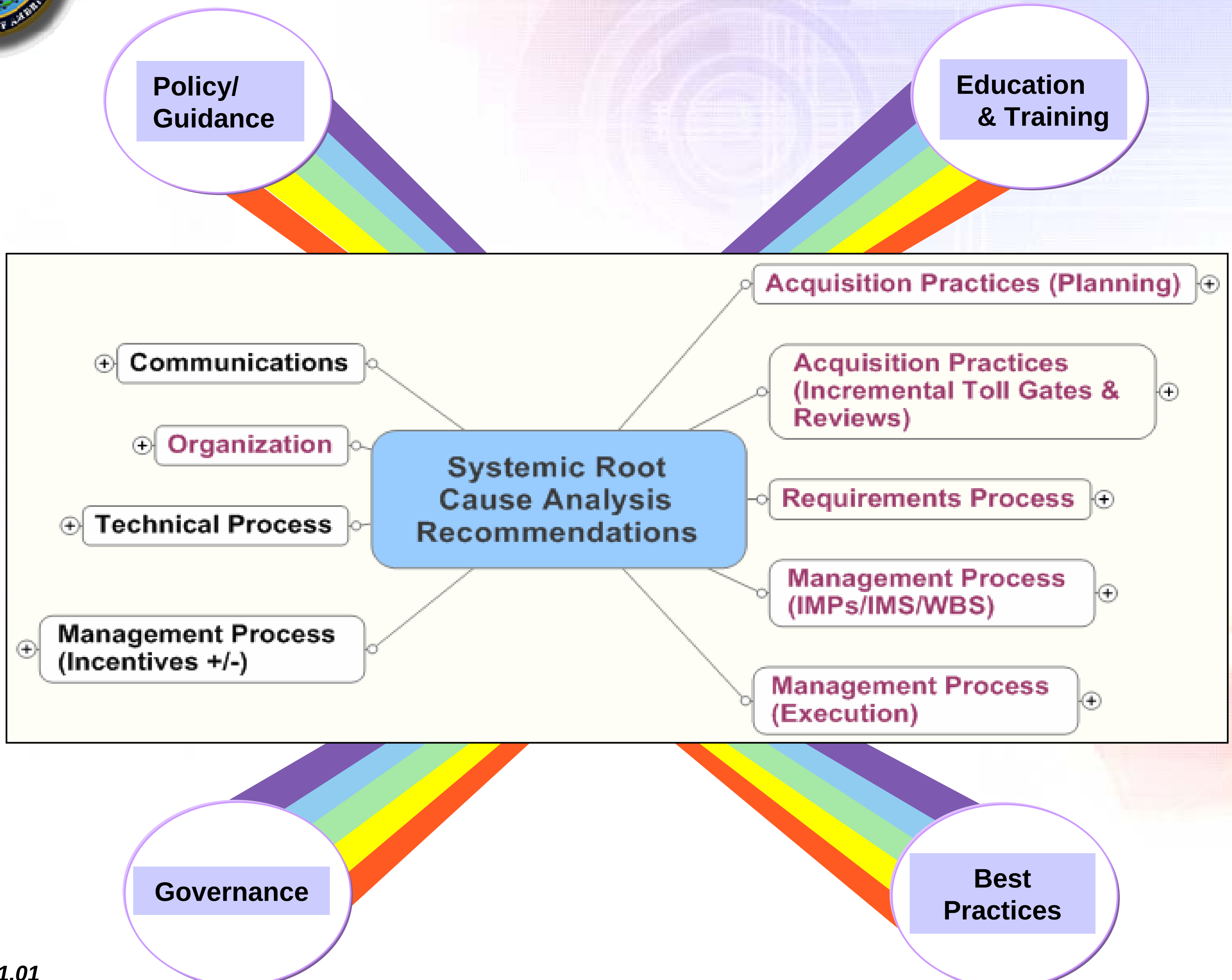
Root Cause Model
(e.g., Poor Business Practices)

Source	Systemic Root Cause (Top 4)	Core Root Cause	Solution Set



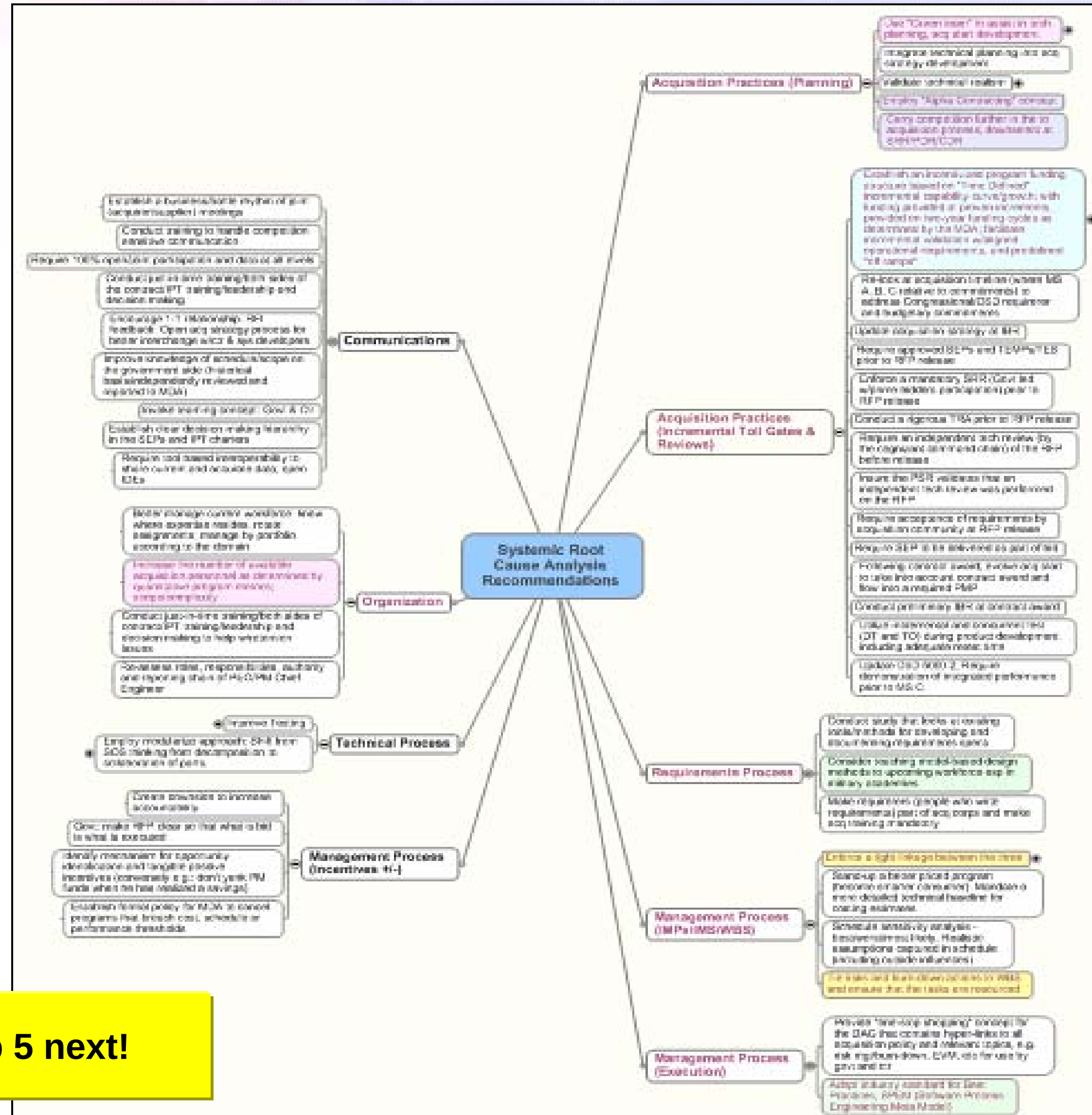
Recommendations Must Address Root Causes at Their Source

Initial Thoughts on Systemic Improvement…



SRCA Workshop Part II - Results

- Over 50 recommendations
  - Varied level of detail
  - Directed at variety of sources
    - » Acquirer & Developer
    - » PM, PEO, Comp. Rep., Acq. Exec
    - » Senior Management to Systems Engineer



Industry panel will discuss top 5 next!

Next Steps

- Develop Action Plan
  - Prioritize the emerging recommendations
  - Assign stakeholders
  - Establish timelines
- Complete analysis on remaining CRC areas
- Formalize NDIA Working Group to continue recommendation development on CRC analysis

Questions/Discussion

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Systemic Root Cause Analysis

Industry Panel Discussion

Panel Moderator: Mr. Bob Rassa

Dave Castellano

Deputy Director, Assessments and Support

Laura M. Dwinnell

Systemic Analysis Team Leader

SYSTEMS & SOFTWARE ENGINEERING
Office of the Deputy Under Secretary of Defense
for Acquisition and Technology

23 October 2007

Industry Panel Members

- Mr. Stephen Henry
  - Northrop Grumman: Principal Engineer
- Mr. Brian Wells
  - Raytheon: Chief Systems Engineer
- Mr. Per Kroll
  - IBM: Manager - Methods IBM Rational
- Mr. Paul Robitaille
  - Lockheed Martin: Director of Systems Engineering Lockheed Martin Corporate Headquarters; President, INCOSE
- Mr. James Burgess
  - Boeing: Systems Engineering Senior Manager, Leader of the Boeing Systems Engineering Best Practices Initiative Boeing Integrated Defense Systems

Results – SRCA Workshop Part II

5 "Heavy Hitter" recommendations include:

1. Increase or improve competition – down select at SRR/PDR/CDR
2. Provide mechanisms for better performance & Implement consequences for non-performance
   » Increase use of toll gate reviews with off-ramps and specific guidance/requirements
3. Ensure better definition and verification of requirements. E.g. use meta-language, SE-based modeling, etc.
4. Require more close coupling of the IMPs/IMS/WBS
5. Increase acquisition workforce and expertise
   » Use "green teams" to augment needed acquisition expertise

When is Extended Competition Cost Effective?

Program Complexity & SW Growth	ATP	SRR	PDR	CDR
Medium High Complexity Holchin Level 7*	188%	144%	122%	111%
Down Select Cost Savings Medium High		34%	31%	-3%
Medium Low Complexity Holchin Level 3*	144%	122%	111%	106%
Down Select Cost Savings Medium Low		12%	-2%	-42%

* SW Growth Based on Holchin Growth Curve Average Growth

Questions/Discussion

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Systems Engineering in the Cognitive and Social Domains of NetCentric Operations

Abe Meilich, Ph.D., C.C.P.

Lockheed Martin Corporation

Simulation, Training, and Support

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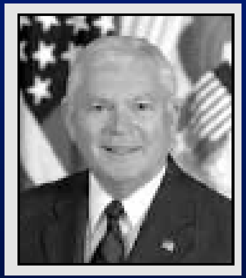
National Defense Industrial Association
10th Annual Systems Engineering Conference
San Diego, CA
October 24, 2007

So, Where Do We Go From Here?

"<u>Becoming net-centric is not about replacing the warfighter with technology</u>. We will, for example, still need boots on the ground. Net-centric operations will allow humans to leverage information to better deal with unanticipated challenges, needs, partners, and circumstances."

"Enabling Technologies for Net-Centricity – Information on Demand", John Grimes (Department of Defense Chief Information Officer), CrossTalk, July 2007



Topics

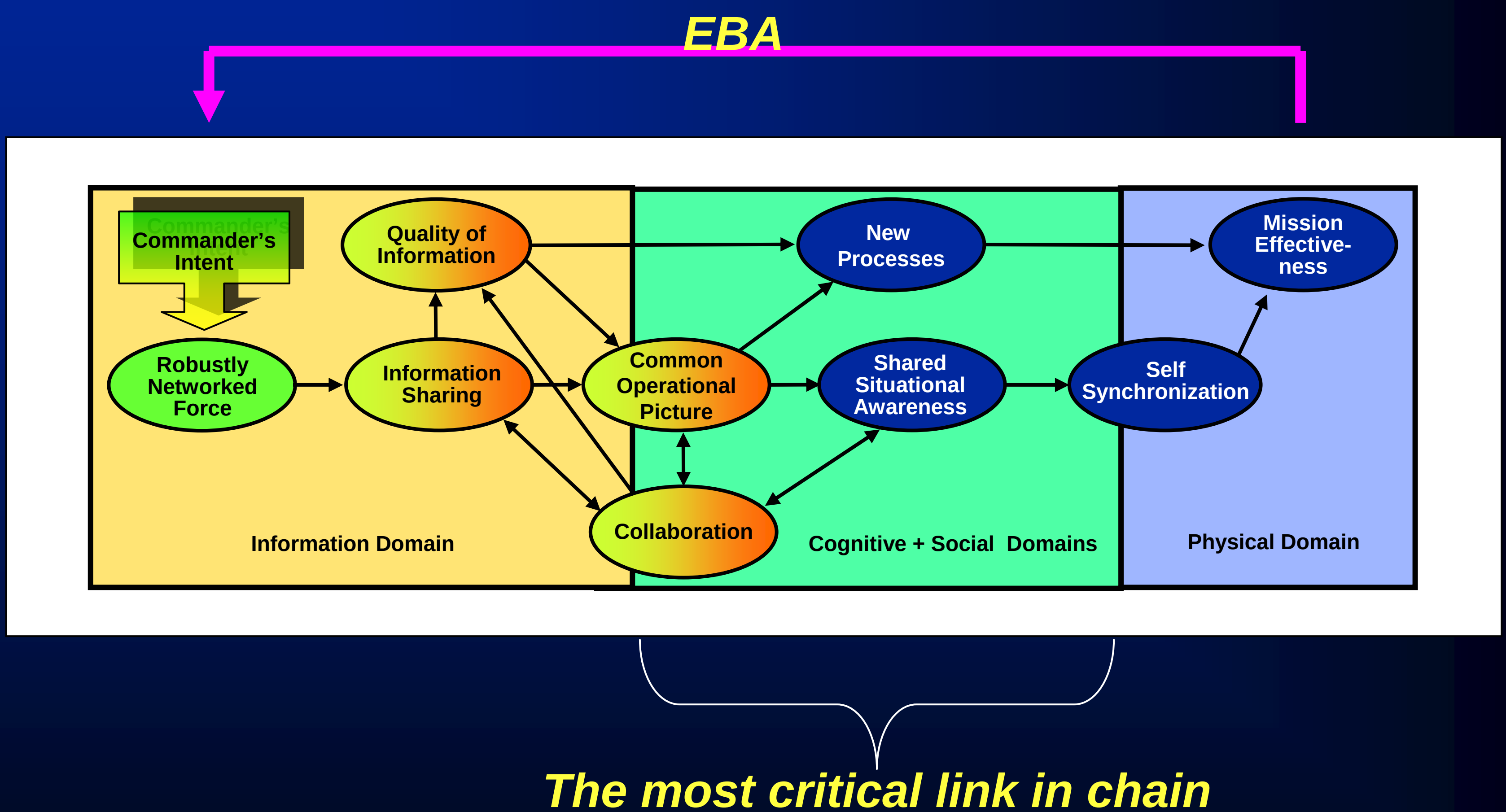
- NCO and Humans in the Loop (HITL)
- The Human As a Key Consideration in SoS
- Observations on Human Systems Integration (HSI)
- Implication from DOTMPLF on System Engineering
- Applying HSI
- Observation from the Perspective of Operations Analysts
- Considerations for Systems Engineering
- Observations on Experimentation
- Summary Comments on Engineering in the Cognitive and Social Domains

Background

- **Net Centric Operations implies**
  - Leverage SoS in new and different ways
  - "Potential" for decision makers and operators to
    - Unprecedented access to information and assets over the network
    - More effective and efficient human "networking"
    - Does Faster information yield smarter decisions?
    - Leveraging ubiquitous and COI-specific services with pre-engineered interoperability in new and different ways
      - For the human this will require semantic interoperability; among many other interoperability attributes
- **Bottom Line Goal >> "The DoD's NCE is a framework for human and technical connectivity and interoperability that allows DoD users and mission partners to share and protect information and to make informed decisions." ***
- **Engineering for the Human –In-The-Loop (HITL) in a SoS**
  - Evolving area of research
    - But, implementation of SoS ahead of application of theory of networking over the SoS
      - e.g., in NCO - more sources, more deconfliction, more sensemaking required
    - Solution: Historically, engineer through experimentation
    - Dilemma: But what do we need to measure and for what purpose?

* "*DOD NetCentric Services Strategy:* Strategy for a Net-Centric, Service Oriented DoD Enterprise", DOD CIO, Washington, DC, May 4, 2007.

NCO Value Chain



The Human As a Key Consideration in SoS

- Collaborative decision-making and shared situation awareness amongst the human operators. – key to SoS*
- More research in human system interaction and decision-making is required to understand better how to integrate these elements into an effective system-of-systems architecture.
  - Systems Engineering: human-machine interface (HMI) was the focus for a single system; human-to-system and human-to-human interaction is the focus for SoS
- Think of the OODA** Loop:
  - **How do we engineer a capability to improve the OODA without considering the HITL?**
  - **Clearly, the cognitive processes that allow the human to perceive and decide are at the center of the human dimensions of war**
  - **Remember: Capabilities are written in terms of what the human needs to accomplish , not what the machine must do**

*** US AFSAB, Executive Summary and Annotated Brief, SAB-TR-05-04, July 2005**
**** OODA: observe, orient, decide, act**

The Human As a Key Consideration in SoS

- Including human system interaction as a part of System-of-Systems Engineering continues to be an important design parameter
- How do we design around the ad hoc, transaction-oriented situations that are common in military situations?
    - Many designs assume a fixed scenario as the basis for design ala DODAF
        - DODAF not sufficient for evaluation of “human behavior” utilizing information systems in a SoS environment
    - Systems are designed at the individual-to-system interface; in a SoS, NetCentric environment we should be designing to account for how individuals, crews, teams, units, or organizations interact with the systems, and in a context of a SoS

Observations on HSI

- SOSE must be done in a context of users, operators, maintainers, and support personnel in operational environments which may complementary as well as have conflicting needs
  - Total ownership costs includes all of the above
  - Many do not want to consider all the above, since it may drive up total ownership costs of a proposed or envisioned SOS
  - Above and beyond the technology implementation of a single system we have the effects of security and safety (both driven by human behavior) multiplied – but, that is the value that SOSE brings to the table
- HSI ensures that human-centered domains are integrated throughout system design, development, manufacturing, operation, sustainment, and disposal
- HSI seeks to treat humans equally with other system elements, such as hardware and software, in system design

***INCOSE Handbook, 2007**

Observations on HSI

- "Effective front-end analyses start with a thorough understanding of the mission of the new system, successes or problems with any predecessor systems, systems with which the proposed system must interface, <u>and the knowledge, skills, abilities, and training associated with the people who are likely to interact with the proposed system</u>." *
  - In addition, we must multiply the complexity of this analysis in a SoS
- There is controversy amongst the HSI discipline practitioners as to how HSI works in conjunction with SE (i.e., is it a separate discipline that comes in after SE or is an integrated discipline within SE?)

**INCOSE Handbook, 2007*

Observations on HSI

- "Complexity is a reality in systems design and systems engineering and even more so in considering the multi-faceted human component considerations of a system" *
- The Challenge in the design of SoS:
  - Engineers will need to make all new systems "net-ready" for the net-centric environment, and capable of working with a <u>wide array of existing and evolving systems</u>
    - Each of which were <u>optimized for different sets of human interactions with their respective systems</u>, which may be at odds for cross-systems integration and use
    - Of critical importance is the ability to integrate and synthesize data from multiple systems and sources into useful information that can be employed by humans for effective decision making – i.e., the semantic interoperability problem

***INCOSE Handbook 2007**

Implication from DOTMPLF on System Engineering

- NetCentric SoS implies breaking organizational barriers
- The key human element here is Trust
  - We must not only re-engineer our system to leverage NetCenricity, we must also re-engineer the enterprise
    - Will the system from organization A be there (availability and QoS) to support the system from organization B?
- Today – Mismatch between rate of applying technology to the problem versus the organizational and business implication of the transformation
  - All facets pf DOTMPLF must be re-evaluated when a new capability must be assessed against NetCentric principles

Applying Human Systems Integration (HSI)

- Advances is practice of HSI are beginning to provide the capability to quantify and measure human characteristics. These newer methods also allow better decisions to be made early in the design and development process where changes are relatively inexpensive to make."[1]
  - Need: Greater focus on HITL as a measurable component of capability MOE and its implementation in SoS (systems + humans) MOP
  - Trend: Systems and products that can be operated and repaired by fewer people, by lesser skilled people, and/or people with lesser training will be in greater demand.
    - Manpower, personnel, and training (example: UAV and takeoff/landing expertise) are becoming key consideration in cost effectiveness and mission effectiveness
- Need to make the human component an "inherent part of the system," and the drive toward "quantification of people variables" in the overall system engineering of the system or SoS
  - In an era where "technology will solve the problem" it is a challenge for technologists to integrate the contributions of the soft sciences in the design of military systems that allow deterministic design solutions based on physics or bits/bytes.

[1] *"Handbook of Human Systems Integration", Harold Booher, Wiley & Sons, 2005*

Applying Human Systems Integration (HSI)

- NetCentric SoS - The human is now taking an active and leading role in combining systems (and or services) to provide new capabilities (at run time versus at design time)
  - For the HITL today, this is art; depending on the COI and availability of new evolving services.
  - Can we bring science to this?
  - Passing Power to the Edge – implies new training paradigm with new SoS assets to configure and use.
  - Commanders are challenged to plan tasks in hours vs. days; planning in minutes versus hours
    - Paradigm shift: Less decision and information flow up and down the chain of command
    - Commander now “shepherds” or “monitors” versus “commands”
    - What is the minimum information required to make decisions at the Edge? – An area of intensive research and experimentation
  - How do we capture and analyze the impact of an operational architecture, and its complementary system architectures, when we are asked to accommodate responsive, agile, dynamic (on-the-fly changes to) operational approaches in a NetCentric environment?

Applying Human Systems Integration (HSI)

- "….it can be expected that HSI activities will become more closely associated with constructive, virtual, and live simulations" [1]
  - Measurement of Human-in-the-loop parameters (primarily cognitive and social parameters) in the field has been problematic for SEs to define, apply, and measure
    - Not enough time and motion studies in battle as opposed to measuring business processes in a factory
  - Experimentation, in lieu of engineering, has been pursued
- Where can the contributions in decision theory help SE a SoS?
  - "Blink" >> What does this tell us?
    - Do people blindly look at and process data given to them by machines that will anticipate their needs?
    - What filters are on? >> varies from individual to individual
      - How can this be reproduced and designed to?
      - Is experimentation our only route to understanding?

[1] "Handbook of Human Systems Integration", Harold Booher, Wiley & Sons, 2005

Observation from the Perspective of Operations Analysts[1]

- **Key challenge of SE of information systems is: How do we support decision making to improve mission effectiveness**
  – Decision making tasks
    - How much information is enough to make a decision?
    - The lower the tolerance for risk, the higher the demand for information to avoid that risk
    - Commanders process information differently, therefore, information must be shaped for the individual commander
  – Tasks do not always require quantifiable information
  – Just because something cannot be measured or quantified, doesn't mean it isn't important
    - Qualitative methods, such as observation, have their uses as well
  – Commanders must perform their tasks in a timely manner
    - Concern that they will wait for more or better information rather than act or make a decision
    - Need to balance the need for quick decision making with informed decision making

[1] Derived from: MORS Workshop Report: How Cognitive and Behavioral Factors Influence Command and Control, Military Operations Research Society, 22 April 2005

Observation from the Perspective of Operations Analysts[1]

– On the Network - Email, phone, and chat proliferate workload irrespective of the chain of command
  - Increased capability may decrease effectiveness (e.g., more technology, information overload)
– Concern - <u>In Network-Centric Warfare, everything depends on the network - What if it doesn't work?</u>

[1] Derived from: MORS Workshop Report: How Cognitive and Behavioral Factors Influence Command and Control, Military Operations Research Society, 22 April 2005, p.22

Considerations for Systems Engineering

- **System Engineering tradeoffs**
  - Drivers in the problem space
    - Changing nature of military operations (sectarian-based urban vs national armies
    - Call for certain cognitive and social behavior
      - e.g., each system optimized for human in system-specific domain; SoS human behavior subject of research
  - Requirements in terms of the human component of the architecture
    - As opposed to mission, task, or technology
      - Examples
        - Agility and adaptability refers to the human, rather than the command and control process
        - Distributed collaboration refers to the people who collaborate, rather than the tools used to collaborate
  - Technology can work well, but still not contribute to battlefield performance

Considerations for Systems Engineering

- **Cognitive engineering (sometimes called cognitive systems engineering) is a multidisciplinary endeavor concerned with the analysis, design, and evaluation of complex systems of people and technology.**
  - It combines knowledge and experience from cognitive science, human factors, human-computer interaction design, and systems engineering.
  - focused on how people actually interact with complex technical systems
  - Human-computer interaction became a recognized field within computer science
  - That is, design must be based on the observation and understanding of system users "in the wild." *
  - The inherent systems approach of cognitive engineering means that the human user must be understood in the context of task, tools, and work environment.
  - In recent years, these approaches and methods have been applied to prevalent issues of information overload and sense making.

**** Cognitive Engineering: Understanding Human Interaction with Complex Systems***
John R. Gersh, Jennifer A. McKneely, and Roger W. Remington,
Johns Hopkins APL Technical Digest, Volume 26, Number 4 (2005)

Considerations for Systems Engineering

- On the network, the individual or group Goal-based performance is reached by facilitating information transmitting seamlessly as knowledge to the decision maker.
  - As such, the human needs be actively involved in information transformation by combining his/her experience with available information to generate useful knowledge.
    - Pushing information alone will not accomplish this
    - A fundamental tenet of Net Centricity is that it must be ubiquitously available on demand (available for pull).
    - Therefore, <u>ultimate systems performance depends on the human element processing</u>

Observations on Experimentation

- “All too often designers are left with the choice of assessing human-system performance in expensive full-mission simulations or by estimating human capabilities from handbooks and guidelines. Neither approach has proven satisfactory. Increasingly, DoD and NASA sponsors have been supporting the development of computer simulation to explore joint human-system performance. In such simulations human behavioral characteristics are represented in a computer model of the operator.”
- “the research loop from understanding basic human information processing to observing and analyzing technology developed in support of that understanding is intertwined with engineering and design primarily through the development of prototypes.”
  - So the key research debate today is: Will measurement of human performance as a byproduct of mission (Live/Virtual/Constructive) exercises or modeling &simulation of human behavior provide the greatest feedback to effective system of systems design and orchestration in a SoS environment

* *Cognitive Engineering: Understanding Human Interaction with Complex Systems*
John R. Gersh, Jennifer A. McKneely, and Roger W. Remington,
Johns Hopkins APL Technical Digest, Volume 26, Number 4 (2005)

Observations on Experimentation

Challenge of extracting meaningful data from experimentation with HITL:

- "Decision-making that is rule or algorithmically based can be modeled directly [Augmented Cognition], but error rates should be estimated if humans are involved in the relevant decision-making
  - – Implications for SE: FMEA of technology based on effects of the HITL on Mission success
- Operational knowledge of human issues is still weak in many areas [of C2]. Systematic effort is required for organizing a consistent program for experiments on human issues."[1] [described in 2002 reference; still exists today]

[1] NATO Code of Best Practice for C² Assessment, CCRP, 2002

Summary Comments on Engineering in the Cognitive and Social Domains

- **Observation and feedback**
  - HSI Cognitive and Social - expensive if done late in development of a system; experimentation and modeling needed at the SoS-level during CONOPS development
- **Stimulus/response analysis**
  - Paper simulation
  - War gaming
    - Concept exploration with instrumentation
- **Isolation of components of cognitive domain and social domains**
  - Use NetCentric Operations Conceptual Framework as a starting point

Summary

- We need to provide systems and services to our warfighters quickly, but not without understanding how they are used both cognitively and socially on the battlefield
- This is broader than the Human Computer Interface (HCI) used in systems engineering today
- Just as bio-engineering revolutionized medicine, Cognitive Engineering and HSI as key considerations in systems engineering are, and will, revolutionize the conduct of war on both the strategic and tactical levels of warfare
- Learn more? Good references can be found in the INCOSE SE Handbook in the chapter on HSI

We need to move from system-centered design to human-centered design

Modeling and Simulation Support Plan

David Henry
LM – MS2
Moorestown, New Jersey

Agenda

- Background
- Contents of the Plan
- Conclusion

Background

- More structured planning of M&S needed
- Evidence – Dept. Air Force AFI 16-1002
  - Modeling & Simulation Support to Acquisition
  - SAF/AQI “M&S support Plan Template” 3/29/00
- Some existing program plans call for M&S – placeholder in the document
- Nothing specific or focused strictly on M&S

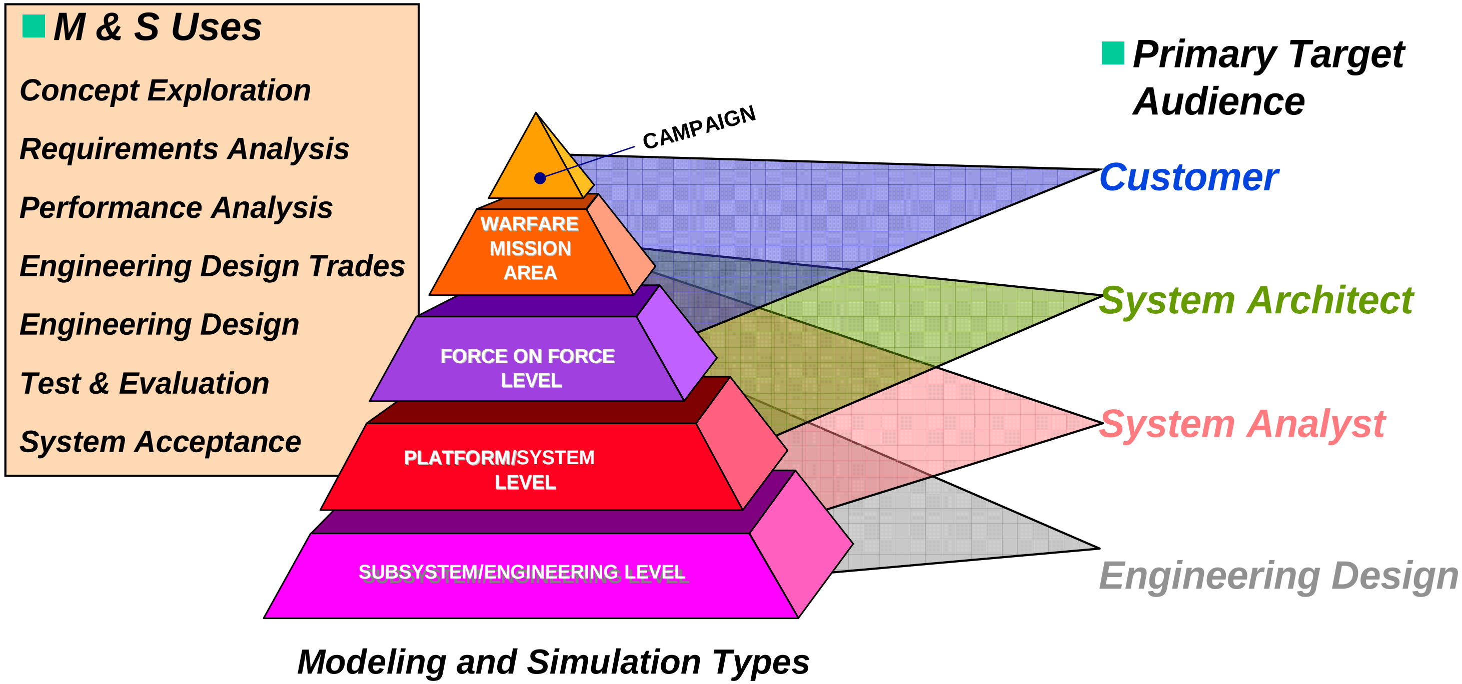
Key Difference: M&S as a product versus as a tool

Background (cont)

- Training community leading the way – mainly simulation "products"
- Test community is growing in its use – also mainly simulation "products"
- Modeling on the rise – typically engineering tools

System Level M&S Context hierarchy gives rise to models becoming end products versus tools – see next chart.

System Level M&S Context (Hierarchy)



Use the Right M&S Tool For The Job

Figure 1

Background (cont)

- A formalized approach / structure is in order
- Certain items need to be addressed
- Will allow for proper evaluation, estimation, and tracking

Contents if the Plan

- Five sections (to discuss)
  - Executive Summary
  - Strategy / Approach
  - M&S Management
  - M&S Activities
  - Infrastructure

There is a sixth section – Funding; breakdown of funding for effort

Executive Summary

- Describe plan contents
- Describe M&S purpose
- High level description of modeled system

Range of context:

From concept, exploration, requirements, analysis, training, and test events, to a formal acceptance

Strategy / Approach

- Describe M&S role in supporting Life Cycle process of the program
- Identify method / approach to be used and any special needs
- Describe the process to field the products to be used

Reference any know processes or procedures already in place

M&S Management

- Program responsibility
  - Program level description – who will lead overall M&S effort down to individual components
  - Description of Boards and Committees
  - Identify expected skill sets / skill mixes

All roles and responsibilities should be described

M&S Management (cont)

- CM/DM
  - – Describe CM process – throughout the life cycle (program most likely will have CM plan)
  - – Describe DM process – throughout the life cycle
  - – Should include
    - Process to verify consistency / correctness of data
    - Appropriate representation
    - Process to certify data

Reference any know processes or procedures already in place

M&S Management (cont)

- V&V
  - – Specific to M&S components
  - – Accreditation – V&V must be explicitly identified

    (Direct connection to Accreditation Plan)
  - – Other program plans most likely to be affected

Identify process for comparing M&S against real data & criteria for acceptance

M&S Activities

- Development – software development plan may exist
- Data identification – data flows, constructs, metadata
- Releases – process of M&S release; include security and legal aspects (if applicable); include approval process & procedures, authority for a release
- Events – run for record, program milestones; include external activities
- Tools – what program teams need (analysis and/or event perspective); day-to-day operation, test

Describe and identify as much as possible of the above activities

Infrastructure – 2 parts

- Organizational
  - Support – internal and external
  - Expertise, training, connectivity
- Facilities
  - Space, floor plans/layouts
  - Power/HVAC
  - Computers, test equipment, spare parts
  - Security – physical and/or logical

Should include technology development (road maps) and/or strategies

Conclusion

- M&S can end up being a mini-program of its own
- Processes same as if it is a program
- This approach to capture these items provides focus on M&S

The hinge to continued future success is in the appropriate use of M&S

ASC Engineering Directorate

Integrity - Service - Excellence

Sound Systems Engineering, Assures Proper/Early Producibility

Dr. Thomas F. Christian,
Richard Stepler, Hamid Akhbari
Aeronautical Systems Center
NDIA, 10th Annual Systems Engineering Conf. 23 Oct. 2007

U.S. AIR FORCE

Manufacturing & Quality in Systems Engineering

- Why are we here?
  - Are there really deficiencies in our Systems Engineering Process or is there a problem in execution ?
  - What metrics are our critics using to gauge our performance?
    - Failures to make rate, cost, and schedule in production
    - Unresolved engineering issues from the development phase manifest themselves as cost and rate failures detected during LRIP and Production
  - Fixing the root cause of manufacturing problems means including manufacturing as a mandatory discipline in the System Engineer tool set during design and development

- My perspective on the Past, Present, and Future of Manufacturing and Quality involvement in Systems Engineering

Overview

- Where we were ►

- Where we are ►

- Where we are going ►

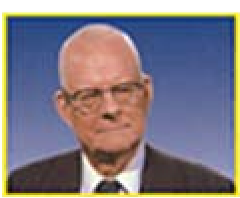
Where We Were: M&Q in America

- Ahhh….”The Good Old Days”?

  …..Were they as “good” as we remember…
  - Separation of design and manufacturing functions
    - Transition to production always problematic
      - LRIP created to address problem but only addressed symptoms
    - Major redesigns of components required to achieve desired production rates
      - Producibility changes euphemism for “we can’t afford to build what you designed”
    - Cost high: low first pass yields and traveled work
    - Schedule fluctuations due to excessive “work in process”
  - Quality by inspection
    - The most expensive and least effective approach
      - Build-test-fix-retest-fix-retest-----who pays for quality

Where We Were: M&Q in America

- Need proof?
  - Back in the 1970s, how long did your domestic car last?
- Corporate commitment to quality and the customer's satisfaction?
  - "What's good for General Motors is good for the country"
- Then came competition from Japan, with help from Deming
- The American auto industry wakes up
  - Recognized Japan's focus on customer satisfaction and quality
- Today: we expect our cars to work every time….all the time
- Toyota is still at the forefront of quality
  - Their "secret" – ***focus on quality and producibility during design***



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Where We Are: M&Q in America

- **<u>FACT</u>**: The American Defense Aerospace Industry has produced, unquestionably, the finest weapon systems in the world
  - But at what cost? How long does it take? How much "cost of quality" have we shifted to operations and maintenance?

"…DoD is simply not positioned to deliver high-quality products in a timely and cost-efficient fashion."

GAO (HASC) Testimony GAO-06-585T "Actions Needed to Get Better Results on Weapons Systems Investments" 5 April 2006

"In 2001, The <u>Average Weapon System Acquisition</u> Program Experienced a 36% <u>Cost Overrun</u> and <u>Schedule Delay</u> of Two Years" – *Dr. Marvin Sambur*

M&Q in the DoD:
Who We Were Then….. and Who We Are Now

- THEN….1975 to 1985
  - M&Q Organization
    - Represented at every acquisition level in DoD
    - Had independent M&Q evaluation of program with veto power
  - Large numbers of experienced people
    - Career field with opportunities
    - Effective Mentoring
  - Tribal knowledge and well documented Specs and Standards

- NOW…..2001 to present
  - Not represented at every acquisition level in DoD
    - No seat and no vote on program readiness
  - Under-represented at most locations
    - No representation at some locations
  - M&Q Specs and Standards cancelled
  - Limited mentoring opportunities and tribal elders retired

GAO Findings: Production Maturity

Program is not taking steps to meet GAO production maturity criteria

Taking steps to meet production maturity criteria

Program demonstrates sufficient production maturity

Program	2003	2004	2005	2006
JPATS		n/a	n/a	n/a
ABL	n/a			n/a
F/A-22				
JSF	n/a	n/a		
Global Hawk	n/a			
JHMCS	n/a		n/a	n/a
Predator B	n/a			
B-2 RMP	n/a			
V-22				

Color ratings based on GAO opinions
Source: GAO Quick Look reports for 2003, 2004, 2005, 2006

n/a = not assessed

Defense Science Board ManTech Study

- DSB was tasked by SAF/AQ to evaluate the ManTech program
- Released report in February 06
- Much of the report pertains specifically to ManTech
- Portion of the report addresses global acquisition manufacturing issues
  - Assessing program readiness for production…..(suggested using the new Manufacturing Readiness Levels (MRLs), more on the MRLs Later)
  - Workforce Expertise – clearly addresses the entire DoD acquisition workforce

Complete DSB report is located at:

http://www.acq.osd.mil/dsb/reports/2006-02_Mantech_Final.pdf

Defense Science Board ManTech Study

Findings:

- Manufacturing talent in the DoD workforce, and its supporting industrial base, has and continues to decline
- Not enough people (both at working level and in leadership positions) understand the processes involved in developing and manufacturing defense systems

Recommendations to correct knowledge deficiency:

- Create policy requiring support for programs such as ManTech
- Implementation of MRLs as part of DoDI 5000.2

War-fighter Expectations

1. Avoid cost overruns, performance shortfalls, and schedule slips typically manifested during production
2. Improve quality and avoid surprises
3. Ensure affordability and producibility
4. Identify all potential MFG risks during transition from development to production and establish risks mitigation plans
5. Provide rapid response to emerging needs, e.g., readiness (includes combat ops, surge, parts and spares, etc.)

Have you met your customers expectations?

Swinging Pendulum of Acquisition Reform

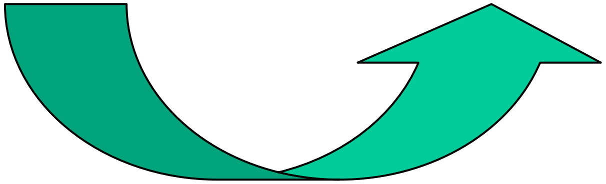
•Where we were was not cheap….but it was defined

•Where we are is neither cheap nor defined

•The faster..better..cheaper "acquisition reform" pendulum… for us a wrecking ball….left M&Q vulnerable

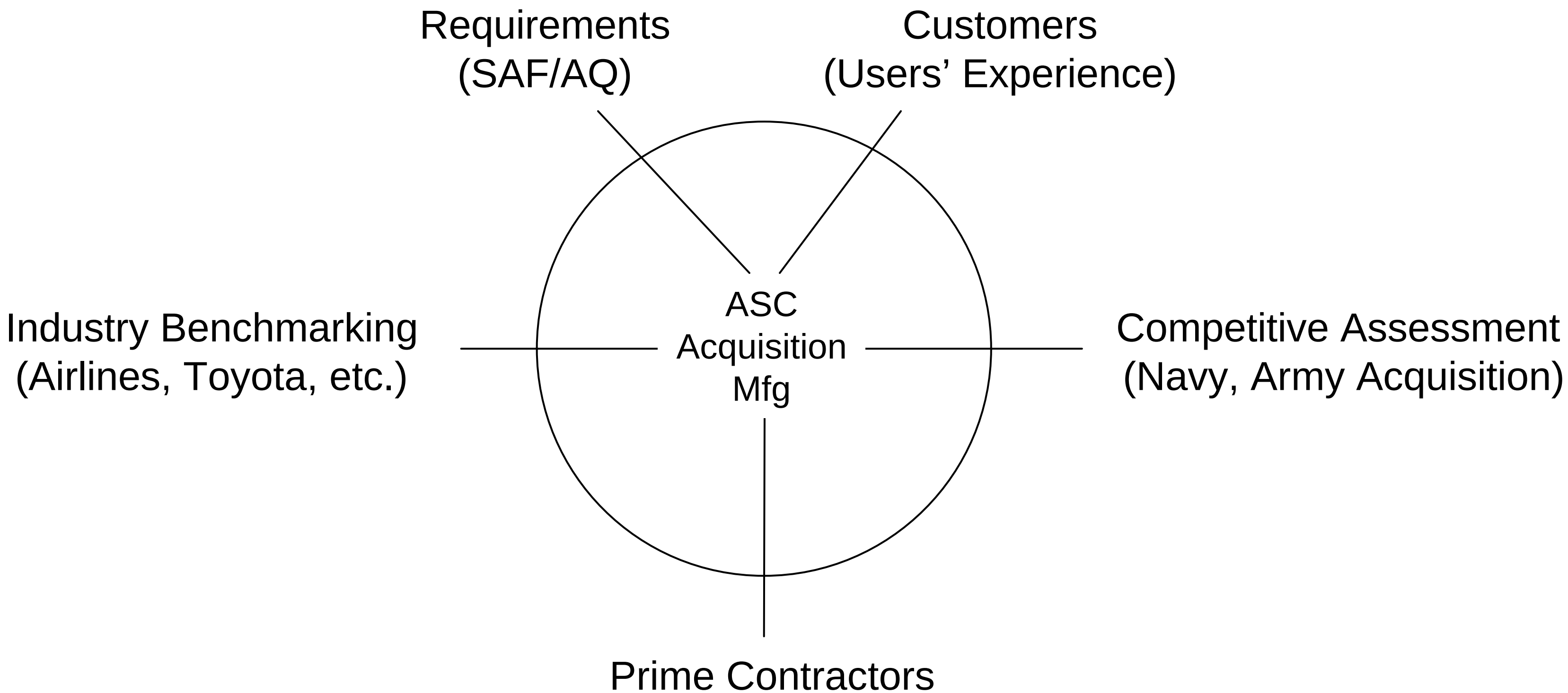
•We can anticipate the return swing but must not let it drive us back to the old approach.

• Let's tailor the "return trip"



ASC/EN Response to War-Fighter Concerns

- ASC/ENSM plans to conduct a 360^o evaluation to identify solutions and best practices



Prime Contractor Messages

1. Government acquisition strategies do not require an in-depth risk analysis for manufacturing during product design.
2. Government does not specify the right deliverables in their contracts.
3. Benchmark other industries to get a better picture on MFG related issues during product development and risk mitigation plans to address them.
4. Assess production readiness in a meaningful way.
5. More emphasis on suppliers during product development.

Prime Contractor Messages

1. Government acquisition strategies do not require an in-depth risk analysis for manufacturing during product design:
   - Establish effective source selection criteria to emphasize producibility and affordability
   - Identify incentives for contractors to focus on producibility and affordability during product development.
   - More MFG/QA emphasis during ASP reviews
   - Strong Government advocate/champion are needed
   - There is a gross lack of knowledge and personnel in this area
   - Hold PMs and chief engineers accountable
   - Educate Government PMs with potential MFG/QA risks and their impacts to the overall system life cycle cost
   - Make long-term decisions thoroughly considering all production risks down the road

Prime Contractor Messages

2. Government does not specify the right deliverables in their contracts:

- Government needs to verify that the contractor has the right processes in place to deliver the right product
- Government does not use the right metrics to measure performance
- Make the contractor demonstrate that they have a solid production plan
- Require the prime to demonstrate control of MFG processes during development
- Specify proper MFG/QA contractual requirements in development contracts

Prime Contractor Messages

3. Benchmark other industries to get a better picture on MFG related issues during product development and risk mitigation plans to address them:

   - Consider world-class performers in other industries
   - Think outside the box
   - Develop lessons learned
   - Evaluate commercial programs and practices as well as the FAA
   - Consider having budget for "Producibility Improvement Plan" (PIP)

Prime Contractor Messages

4. Assess production readiness in a meaningful way:

- Government needs to develop better MFG transition strategies
- Willoughby templates (Transition from Development to Production) are useful tools
- PRRs are not focusing on the right parameters. Many programs do not conduct full blown PRRs like they once did
- MRLs will be a useful tool once up and running
- Government PMs should be required to develop MFG exit criteria for milestone reviews
- Industry recognizes “Production Plans” once required by the Government for most programs as a useful tool

Prime Contractor Messages

5. More emphasis on suppliers during product development:

- The vast majority of quality related issues come from lower-tier suppliers. Ensure that the prime's processes for management of their suppliers are solid
- Properly manage requirements flow-down to lower-tier suppliers
- Require suppliers participation on IPTs during product development
- Ensure supplier participation in the systems engineering process, in particular MFG processes and procedures
- Develop predictive indicators to assess supplier's "internal health"
- Use of common metrics

Where We Should Be Going

- **The way forward…..**
  - Internally: Manufacturing and Quality must be the responsibility of design engineers and be considered early in the development process
  - Externally: Supplier Management….engineers at primes must partner with suppliers to achieve maximum affordability

  - To help with all of it: The M&Q tool set:
    - Manufacturing Development Guide-Available now
    - Manufacturing Readiness Levels-Draft available now
    - Manufacturing and Quality Integrity Program-Available soon

Systems Engineering – Ensure that design meets requirements and ***is producible***

Mfg/QA helps SE meet producibility, OSS&E, and Airworthiness Design requirements

M&Q Tool Set
Manufacturing Development Guide

Best Practices

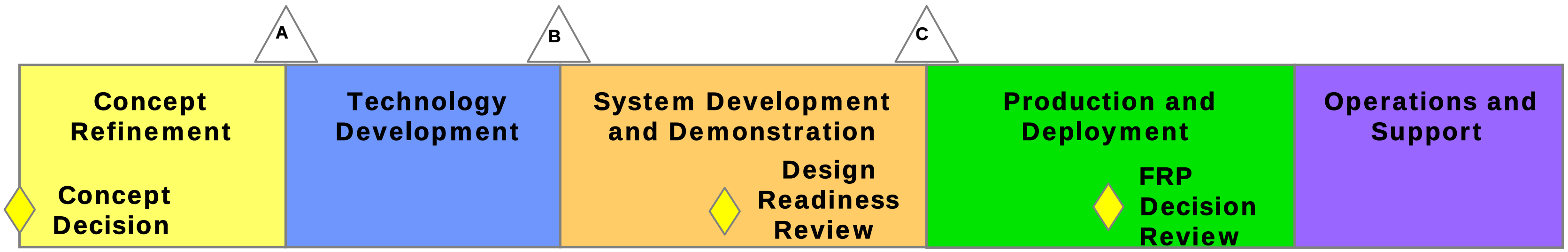
http://engineering.wpafb.af.mil/mdg/mdg.asp

- Mfg Capability/Risk Mgt
- Production Cost Modeling
- Key Suppliers
- Key Characteristics and Processes
- Variability Reduction
- Virtual Mfg
- Design Trade Studies
- Product/Process Validation
- Process Control and Cont Improvement
- Factory Efficiency
- DMSMS

- Developed by a joint industry Government team, improved over the past 10 years
- Recognized aerospace industry guide for describing the role of Manufacturing and Quality in the Systems Engineering process
- Available at: http://engineering.wpafb.af.mil/mdg/mdg.asp

M&Q Tool Set
Manufacturing Readiness Levels

Defense Acquisition Life Cycle Framework



Technology Readiness Levels

TRL 1-3	TRL 4	TRL 5	TRL 6	TRL 7	TRL 8	TRL 9

Manufacturing Readiness Levels

MRL 1-3	MRL 4	MRL 5	MRL 6	MRL 7	MRL 8	MRL 9	MRL 10

MRLs address topics such as:

- Parallels Technical Readiness Levels
- OSD planning to make MRL assessments a milestone requirement
- Available at: https://acc.dau.mil/CommunityBrowser.aspx?id=18231

Producibility
Key Characteristics
Material Availability
Production Simulation
Process Controls
Tooling

M&Q Tool Set
M&Q Integrity Program

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(Project SESS-2006-001)

NOT MEASUREMENT SENSITIVE

MIL-HDBK-DRAFT
DATE

DEPARTMENT OF DEFENSE HANDBOOK

MANUFACTURING AND QUALITY INTEGRITY PROGRAM

AMSC XXXX **AREA SESS**

- Contains the practices described in the Manufacturing Development Guide
- Includes suggested contractual and/or Systems Engineering Plan requirements and verifications
- Will be posted on the ASC/EN public Website

Producibility…M&Q's Contribution to Systems Engineering

- America's Defense Aerospace Industry is #1 in the world. However…
  - Are we be able to buy desired quantities?
  - How many B-2s were originally planned? F-22s? JSFs?
- If we can't figure out a way to build better systems cheaper, we will fulfill Norm Augustine's prophecy:
  - *"In the year 2054, the entire defense budget will purchase just one aircraft. This aircraft will have to be shared by the Air Force and Navy 3-1/2 days each per week except for leap year, when it will be made available to the Marines for the extra day."*
- My primary focus is to integrate quality and producibility early in the Systems Engineering process (see the ASC, MDG)

Encouraging Steps Forward

- Tri services committee being formed at the SES level
- NDIA committee on “ Manufacturing & Quality Assurance formed as government/industry forum.
  - If you share my interest in this subject, join me on the committee
- Fixing the root cause of manufacturing problems means including manufacturing as a mandatory discipline in the Systems Engineering tool set during design and development

Summary: We Know We Are There When…..

- The process used to manufacture a part is given equal consideration as the functionality of the part
- Product performance and producibility are equal in the risk analysis trade studies during product development
- The "chiefs" of design, manufacturing and logistics have equal votes on critical design decisions during development
- "Design" executives are held accountable for unit production cost and cost of quality decisions
- M&Q metrics are present in entry and exit criteria for each phase of the acquisition life cycle
- Integrating people, processes, and technology using the System Engineering Process proven effective by world class producers

As good systems engineers, our commitment to M&Q starts in design

Thank you for your time
and attention

Thomas.Christian@wpafb.af.mil
Phone: 937-255-1826

Implementing a Systems Engineering Risk Program in a Sustainment Environment

25 Oct 07

Jim Miller
Chief Engineer
727 ACSG/EN
Phone: (405) 736-7996
james.c.miller@tinker.af.mil

What Sustainment Environment?

727th Aircraft Sustainment Group

Col. James Fulton
Commander

Ms. Jerri Hulme
Deputy Director

Mr. James Miller
Chief Engineer

PROVIDING EFFECTIVE & EFFICIENT WEAPON SYSTEM SUPPORT

727 ACSG Mission

- Single Manager for Sustainment and Modernization of
  - 400+ USAF Commercial-Derivative Aircraft
  - HF Global Communications System Network
- Preserves FAA Certification and Operational Safety, Suitability & Effectiveness (OSS&E) of Commercial Derivative Aircraft
- 4 Squadrons Manage Services Acquisition

"Cradle-to-Grave CLS Support"

Weapon System Support

727th Aircraft Sustainment Group
Contractor Logistics Support (CLS)

Weapon Systems

- KC/KDC-10
- VC-25
- E-4B
- C-9
- C-12
- C-20
- C-21
- C-26
- C-38
- E-9
- T-41
- T-43
- T-51
- TG-10
- TG-15
- UV-18
- Peace Lotus
- HFGCS

Customers

- AMC
- ACC
- ANG
- AFRC
- AETC
- USAFE
- PACAF
- AFMC
- USAF ACADEMY
- AF FLIGHT STD AGENCY
- ARMY
- NAVY
- US MARINE CORP
- DIA
- DSCA
- FMS
- USSOCOM

727 ACSG Responsibilities

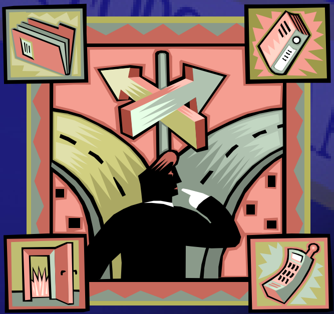
Weapon System's Missions

So What is the Problem?

- Numerous classes, training, & regulations on risk
  - Most aimed at acquisition, not sustainment
  - No detailed direction for a workable, grass-roots approach
- Sustainment different
  - Not one big pass/fail
  - Most new risk associated with mods or unique events
- Our organization had insufficient direction, documentation, and procedures to implement an effective, comprehensive Systems Engineering risk program

So What Are Doing About It?

- Instigated a step-by-step Operating Instruction to implement risk management throughout the organization
- Trained the workforce for common SE baseline
- Implemented tangible approach that is:
  - Aimed at the working level
  - Applicable throughout entire organization
  - Accounts for progress through metrics
  - Always starts with requirements



Workforce Training

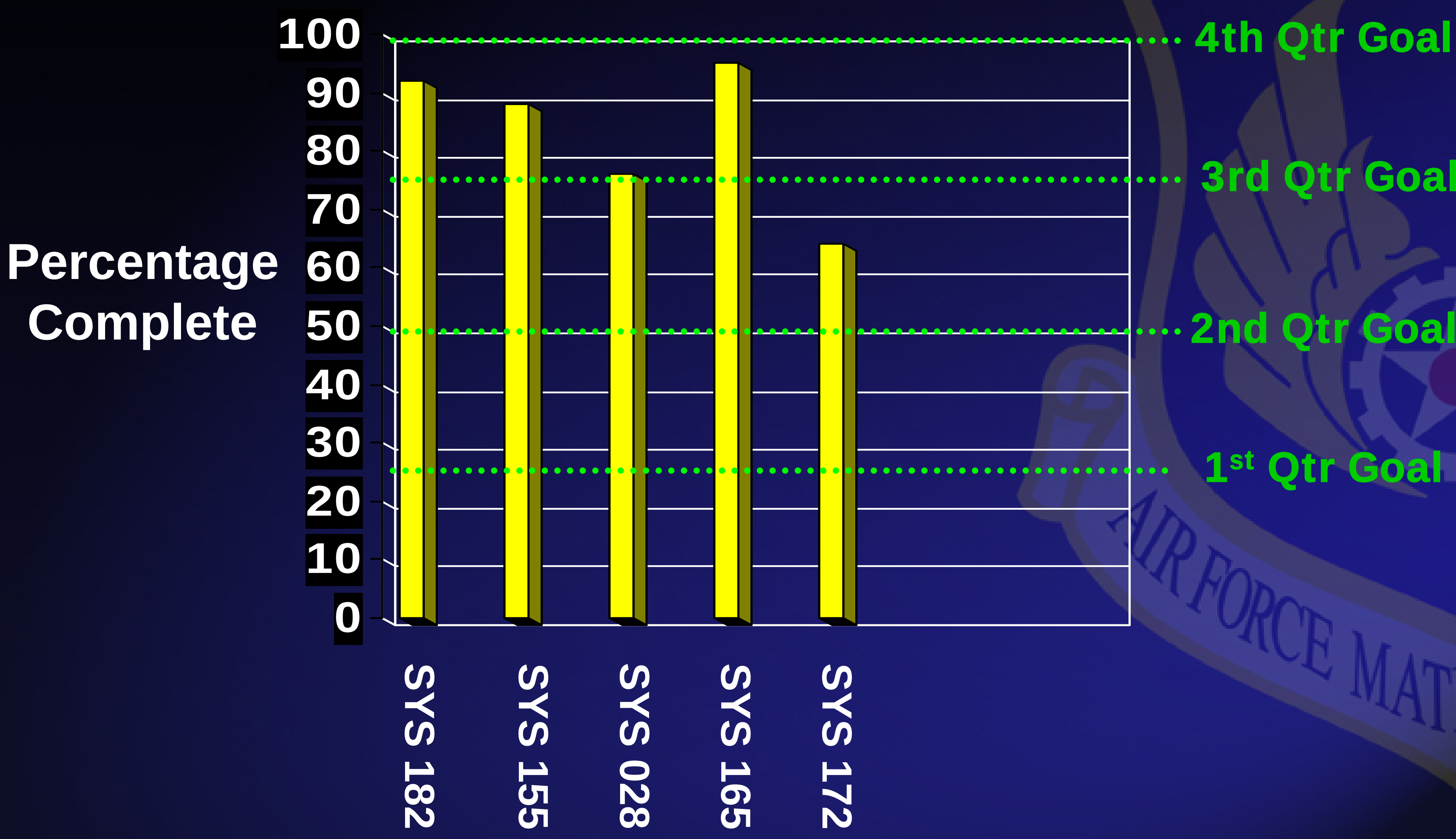
Courses Selected for First Year (All CBT):

- SYS 182 Intro to Systems Engineering ~ 3 hrs
- SYS 172 Modification Management Process ~ 6 hrs
- SYS 155 Operational Safety, Suitability & Effectiveness ~ 9 hrs
- SYS 028 Intro to Configuration Management ~ 16 hrs
- SYS 165 Intro to Risk Management ~ 21 hrs

Who: All PM's, Equipment Specialists and Engineers
When: Complete in 12 months

Workforce Training Metric

Org A Training Progress (45 People)



Risk Management Process

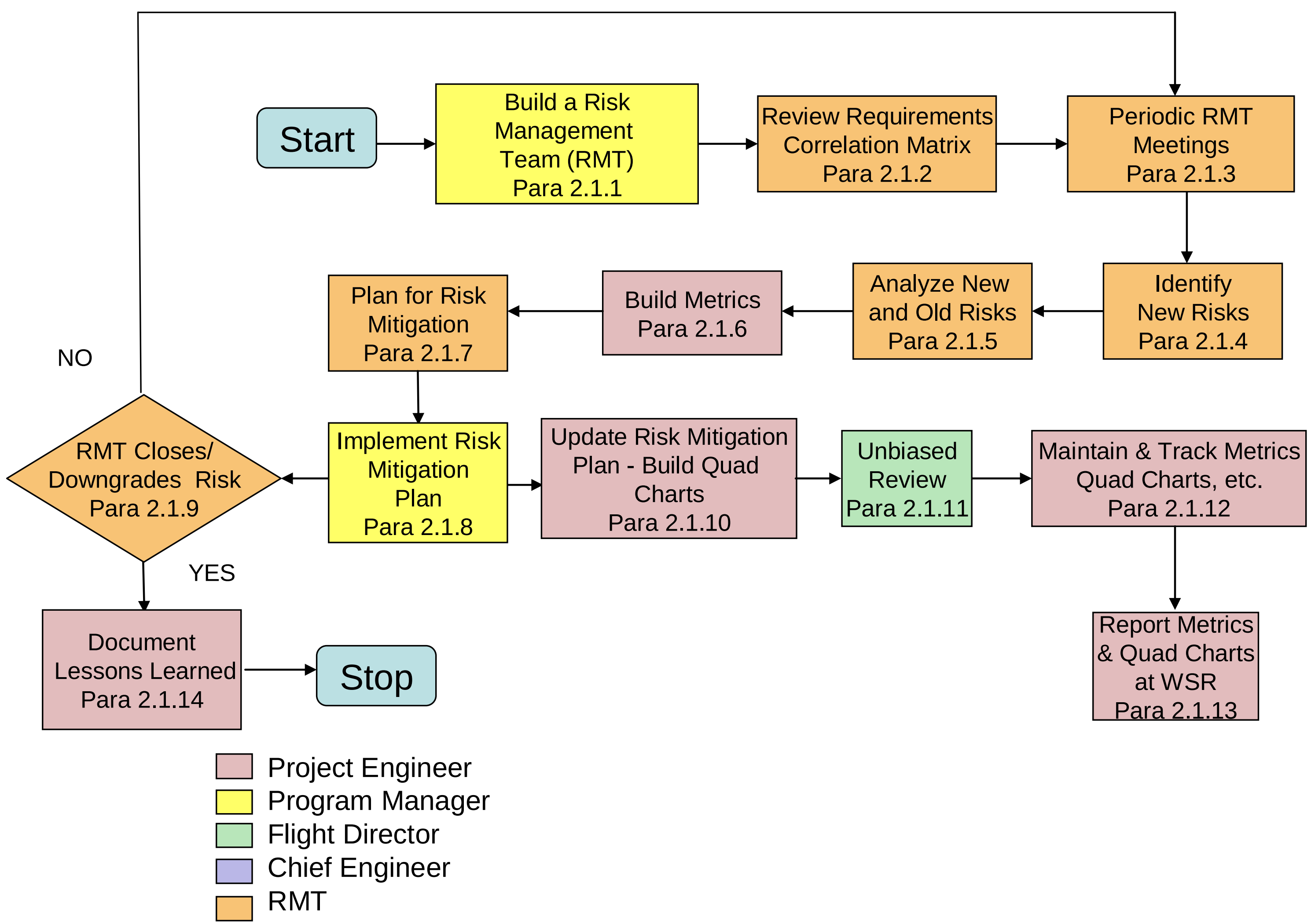


Figure 1. Flowchart for Risk Management Process

Step 1: Build a Risk Management Team

- Program Manager formally establishes RMT in writing
- RMT consists of, at a minimum:
  - Program Manager
  - Project Engineer
  - Representative from the customer
  - Representative from the contractor

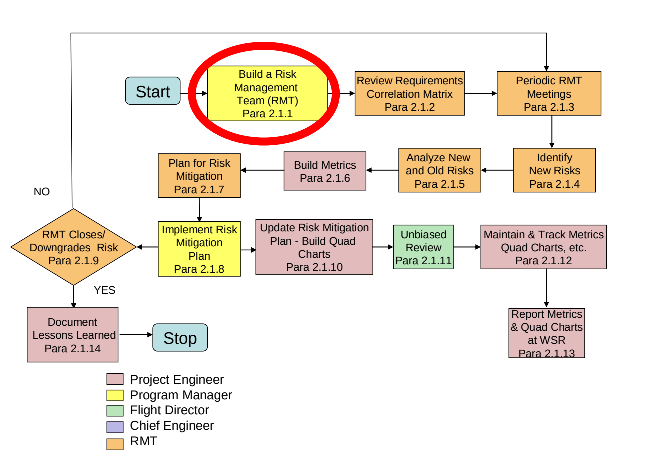


Figure 1. Flowchart for Risk Management Process

Step 2: Review Requirements Correlation Matrix

- Review established RCM
  - Review all initial identified risks assessments
  - Verify initial assessment
  - Determine if all risks have been identified

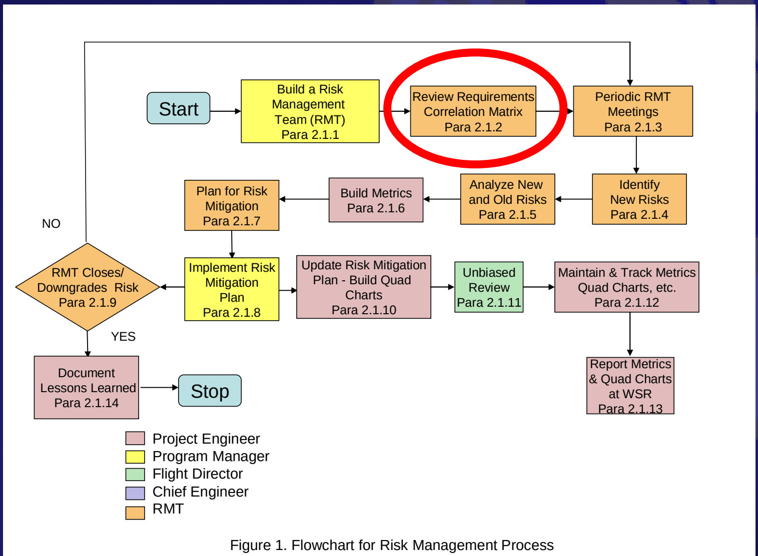


Figure 1. Flowchart for Risk Management Process

Define Requirements

- Break requirements down in a Requirements Correlation Matrix (RCM):
- Spreadsheet with following columns:
  - Requirement
  - Requirement Source
  - Derived Requirements
  - Quantification
  - Operational Conditions
  - Initial Risk Assessment
- Give RCM to
  - Test Team for their planning
  - Risk Mngt Team for their planning

RCM

Req Title	Req Source	Derived Req	Req Definition	Quantification	Op Cases	Risk (R/Y/G)

Program Manager

Project Engineer(s) (Gov & Contr.)

User

Entire Team

Step 2: Review Requirements Correlation Matrix

- Review established RCM
  - Review all initial identified risks assessments
  - Verify initial assessment
  - Determine if all risks have been identified

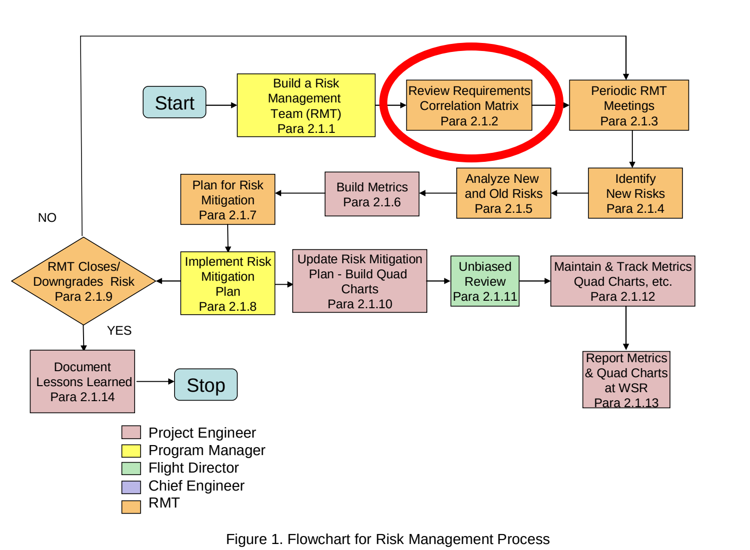


Figure 1. Flowchart for Risk Management Process

Step 3: Periodic RMT Meetings

- Project Engineer shall chair meeting
  - Determine frequency
  - Not less than quarterly to support Weapon System Review (WSR)
- Purpose to:
  - Review all risks
  - Review all mitigation plans
  - Identify new risks
  - Build and update quad charts
  - Close risks

Step 4: Identify New Risks

- Identify any new technical risks
  - Documented requirements
  - Other sources
- RMT can provide input back to RCM
- Other opportunities to identify risks
  - Event driven technical reviews
  - Program management reviews
  - Design reviews

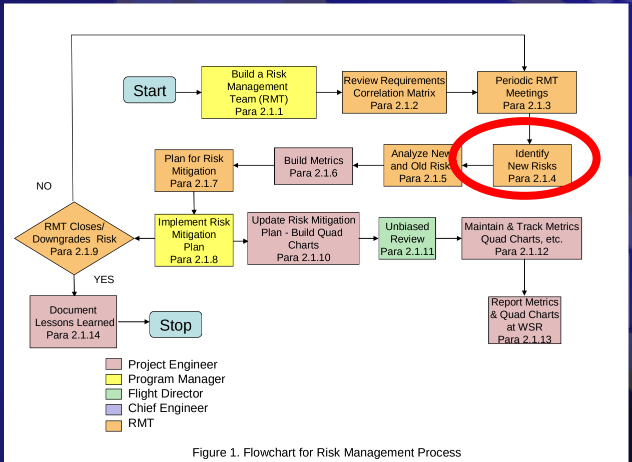


Figure 1. Flowchart for Risk Management Process

Step 5: Analyze Old & New Risks

- Analyze each identified risk
- Use 5 by 5 matrix
  – Consequence if occurs
  – Likelihood of occurring
- Perform Root Cause Analysis for all “red” and “yellow” risks

Step 6: Build Metrics

- Two minimum metrics
  - Risk Assessment Matrix
  - Risk Mitigation Plan Roll-up
- Quad Chart for each yellow/red risk
- Metrics shown to management at quarterly Weapon Systems Review

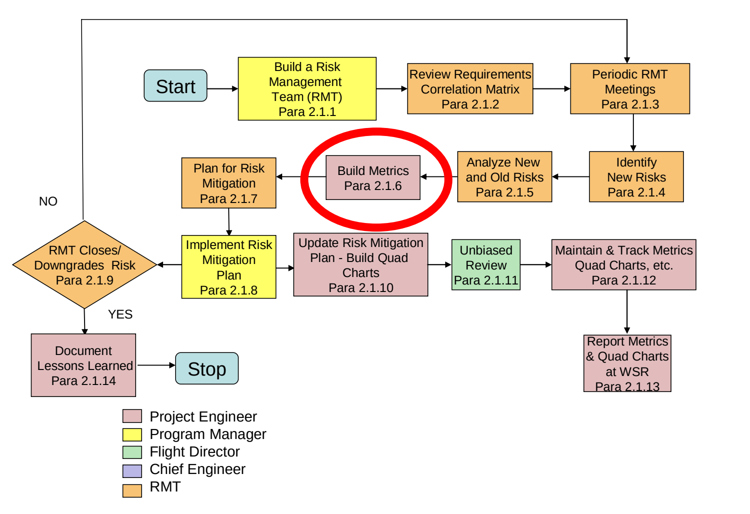
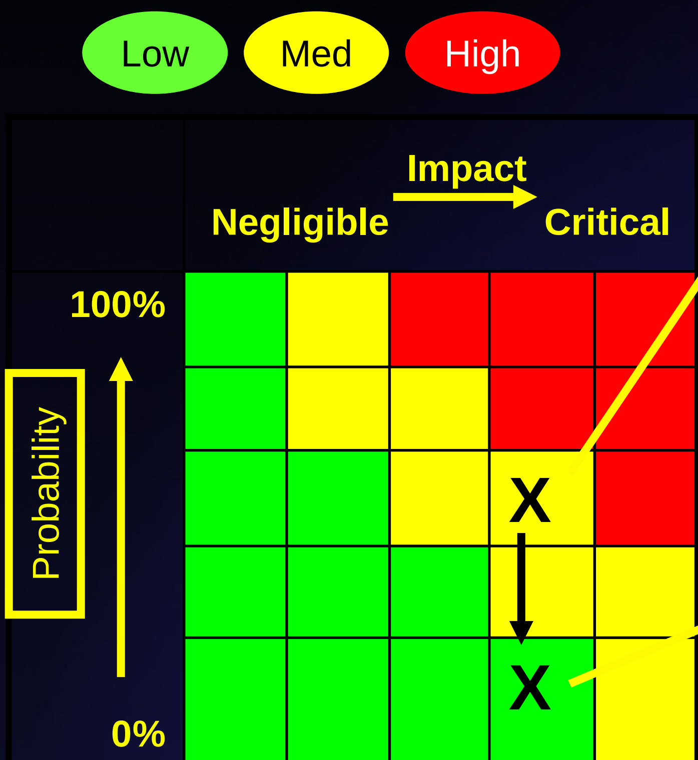


Figure 1. Flowchart for Risk Management Process

Risk #1 Assessment Matrix



Technical Risk: If software complexity increases on MCS then failure of modifications could result.

Mitigation Plan:

- Contractor is currently Capabilities Maturity Model Integration (CMMI) software level 3 certified and has plan to reach level 5 by contract award
- Government will ensure contractor will work with ground agencies to ensure software is interoperable
- Government will follow disciplined requirement matrix process outlined in 727 ACSG Operating Instruction (O.I.) to prevent unplanned requirements/complexity increases & track via established metrics

Risk Workshop Completed – 14 Mar 07

Rick Quad Chart

Risk Title

Risk Tracking Number

G

Risk Color Code

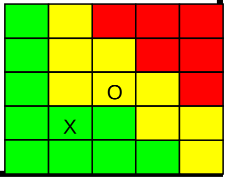
Background

Description of problem

- **Item 1**
- **Item 2**
- **Item 3**

Risk Mitigation Plan

- **Proposed solution for implementation and risk mitigation.**



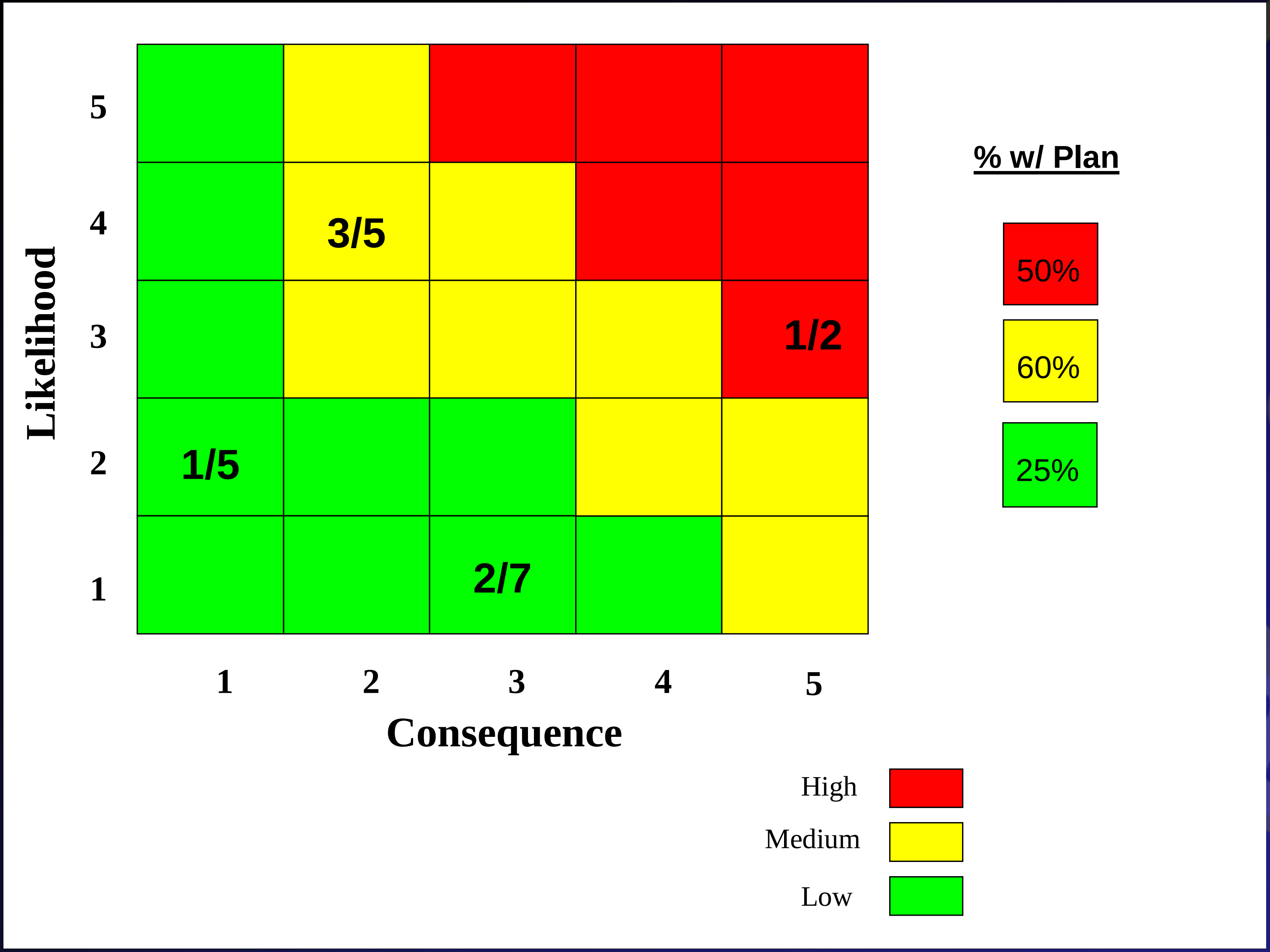
Actions to Date

	Date
• **Established Risk Assessment**	**Date 1**
• **Completed Mitigation Plan**	**Date 2**
• **Completed details of mitigation incorporation with contractor**	**Date 3**
• **Received effort impact (cost and schedule)**	**Date 4**

Future Action

	Proj.Date
• **Contract Award for implementation**	**Date 1**
• **Mitigation Plan Completion (or any significant milestones)**	**Date 2**
• **Etc…**	

Risk Mitigation Plan Roll-Up



Step 7: Develop Risk Mitigation Plan

- Risk Mitigation Plan shall consider:
  - Cost
  - Schedule
  - Safety
  - Effectiveness
- Plan should delineate:
  - Definite courses of action
  - Address the root cause
- Plan should be timely:
  - Within 14 days for high, or red, risk
  - Within 60 days for medium, or yellow, risk

Step 8: Implement Risk Mitigation Plan

- **Program Manager will:**
  - **Work with contractor and/or customer as applicable**
  - **Incorporate into Integrated Master Schedule**
  - **Budget funds accordingly**
  - **Schedule technical interchange meetings as required**

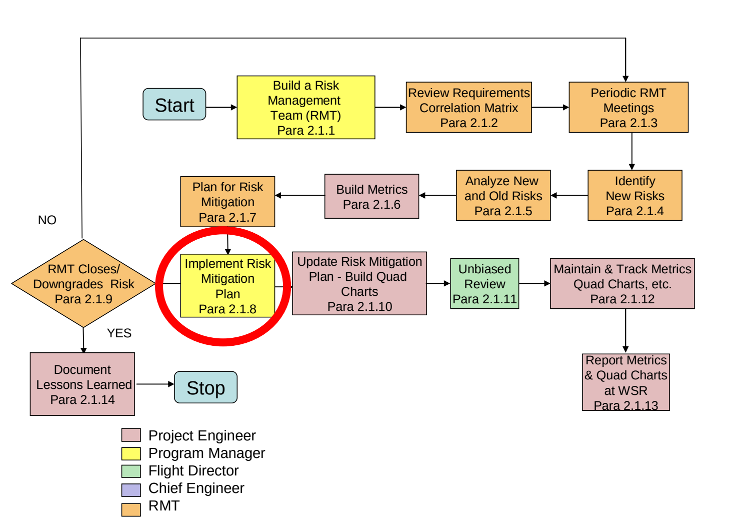


Figure 1. Flowchart for Risk Management Process

Step 9: Update Mitigation Plans/Quad Charts

- Project Engineer will update:
  - Risks
  - Risk Mitigation Plans
  - Quad Charts
  - Metrics
- Quad charts and metrics will be briefed at:
  - Weapon System Reviews
  - Program Management Reviews
  - Others as determined by PM

Step 10: Unbiased Review

- Project Engineer’s boss will set up
- Review will include at a minimum:
  - Chief Engineer
  - Program Manager
  - SMEs within the organization
  - SMEs outside the organization
- Will go thru all risks, mitigation plans, quad charts, and metrics
- Project Engineer will incorporate feedback from review

Step 11: Track Metrics, Charts, Reports

- Project Engineer and Program Manager will update throughout process
- PM will ensure information reported in various venues (WSRs, PMRs, etc)

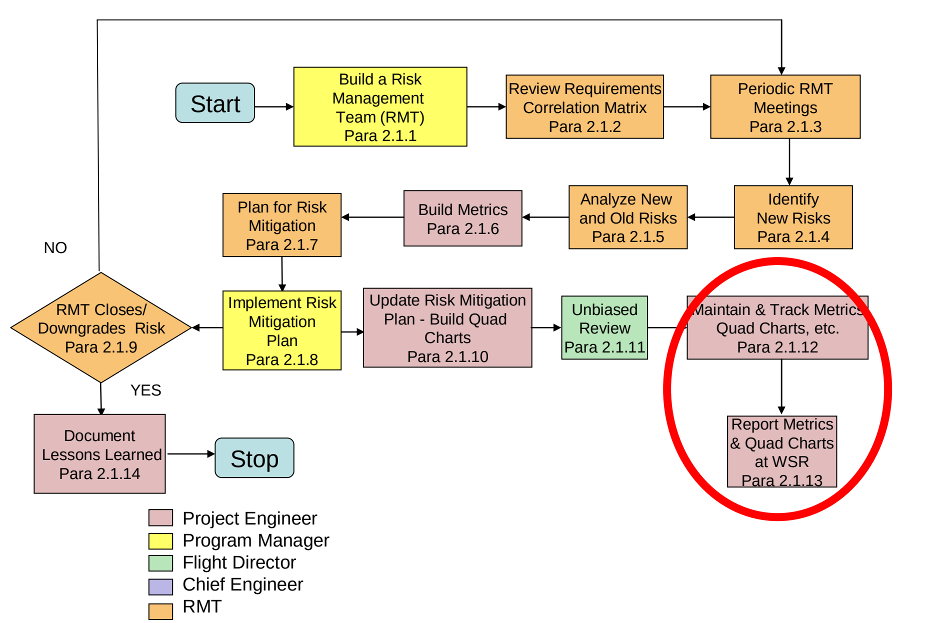


Figure 1. Flowchart for Risk Management Process

Step 12: Lessons Learned

- Risks are not snowflakes
- Mitigation Plans are not either
- Lessons Learned repository contains:
  - Possible risks to consider
  - Potential mitigation plans
- Repository is not program specific, but for entire organization
- Future plans are to make the lessons learned repository a database with keyword searches

What’s Next

- Continue implementation throughout organization
- Continue Measure/Track results
- Populate Lessons Learned database
- Refine as needed
- Document successes
  - We are having some!

Risk Management can be implemented, applied AND make a difference

Summary

- 727th ACSG developed grass-roots means to implement Risk Management as part or our Systems Engineering in Sustainment Environment
- Clear-cut, tangible processes steps for the working-level
- Metrics to measure progress for management
- It works

In Place and In Use Now

Questions ?

Questions ?

Major Modification Programs

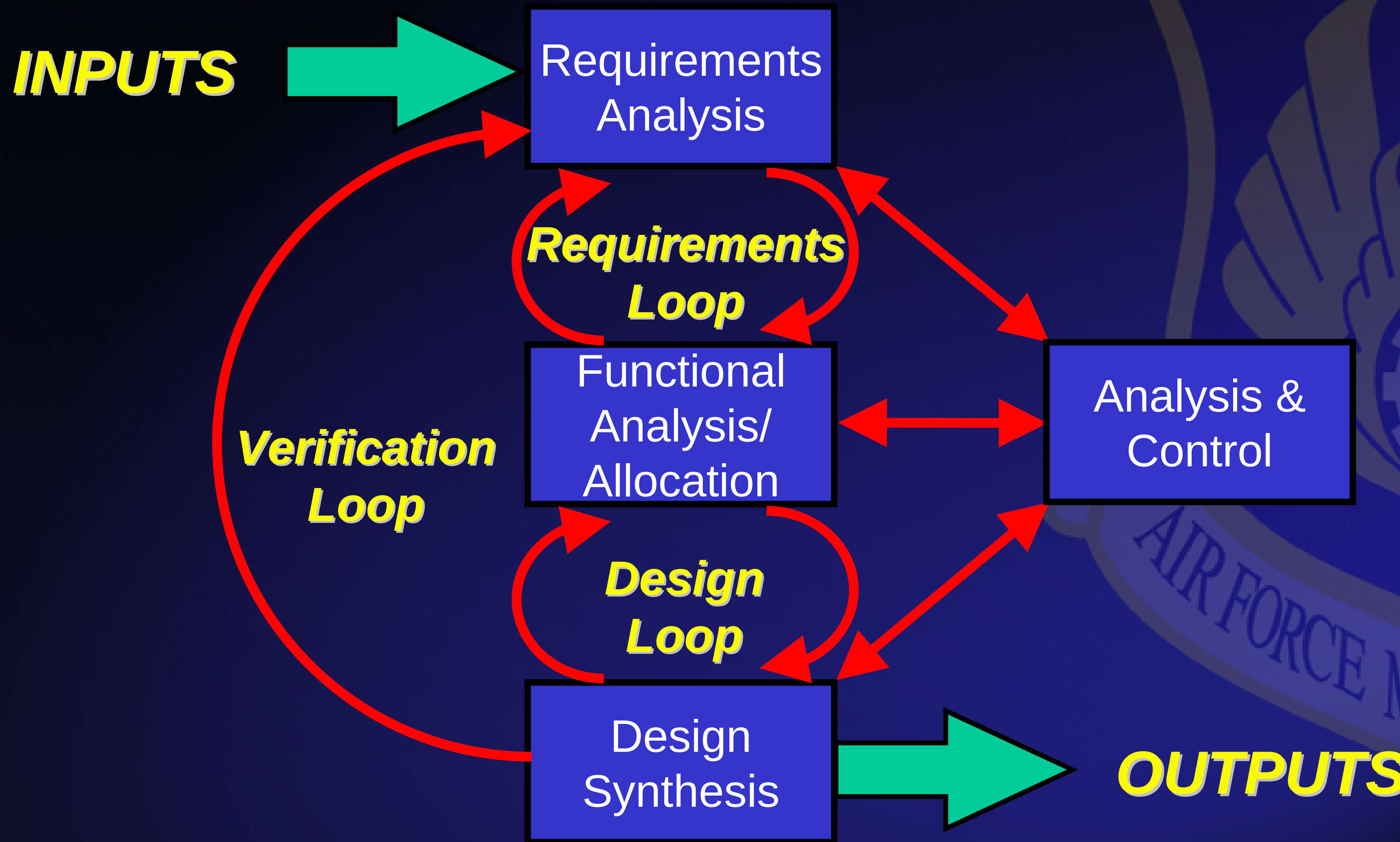
17 Current Programs

Status	Program	Cost
Y	KC-10 AMP – ASC Lead (ACAT II)	$1.03B
G	KC-10 Dual 406 MHz ELT Upgrade (ACAT III)*	$2.4M
G	KC-10 Iridium Phone (ACAT III)*	$2.7M
G	KC-10 UHF SATCOM Antenna (ACAT III)*	$2.6M
G	VC-25 Forward Lower Lobe (FLL) Cooling (ACAT III)	$14.4M
G	VC-25 Presidential Data System (PDS) (ACAT III)*	$223.3M
G	VC-25 CNS/ATM (ACAT III)*	$41.8M
G	C-20 Gulfstream Test Vehicle (GTV) (ACAT III)*	$8.7M
G	E-9 Telemetry Sys Upgrade (ACAT III)*	$5.9M
G	E-4B Mod Block I (ACAT II) *	$421.4M
G	E-4B 256 Kbps High Speed Data via INMARSAT (ACAT III)*	$8.4M
R	C-12 EFIS (ACAT III)	$77.7M
Y	HFGCS Network Control Station – West (ACAT III)*	$23.2M
Y	HFGCS AFSPC Test Range HF Modernization (ACAT III)*	$3.9M
G	HFGCS Network Optimization – Spiral II (ACAT III)*	$7.1M
G	HFGCS Navy Consolidation (ACAT III)*	$6.4M
G	HFGCS Audit Log Upgrade (ACAT III)*	$189K

*Program is fully funded

Phase 4: Identify and Define Processes

Basic Systems Engineering Process



Systems Engineering Implementation Phases

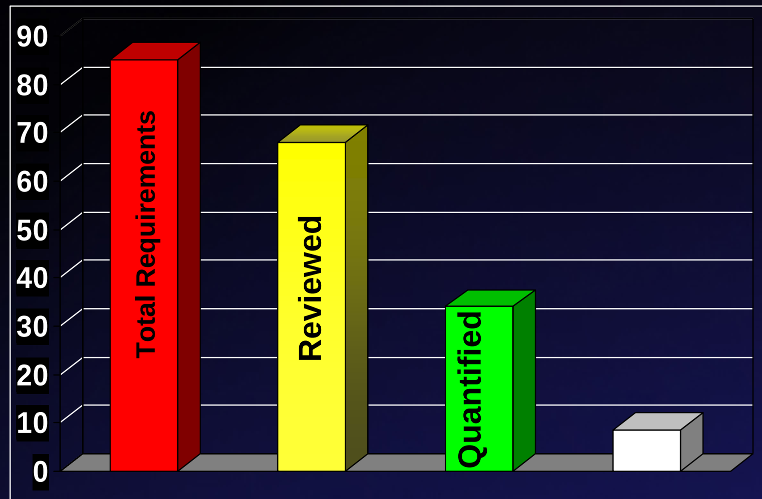
- Phase 1: Awareness of Need
- Phase 2: Workforce Training
- Phase 3: Identify Applicable Programs/Orgs
- Phase 4: Identify and Define Processes
- Phase 5: Incentivize Contractors/Partners
- Phase 6: Develop Library of Tools
- Phase 7: Track Progress via Metrics

Phase 6: Develop Library of Tools

- **Need good SE “toolbox”**
  - Templates
  - Metrics
  - How-to’s (fishbone, 5-whys, paredo, …)
  - Lessons Learned
  - Explanations
  - Best Practices
  - Peer Review
  - Case Studies
  - Life Cycle Cost consideration
  - Contractual language
  - Etc…

Functional Office to Develop/Obtain….Not Started Yet

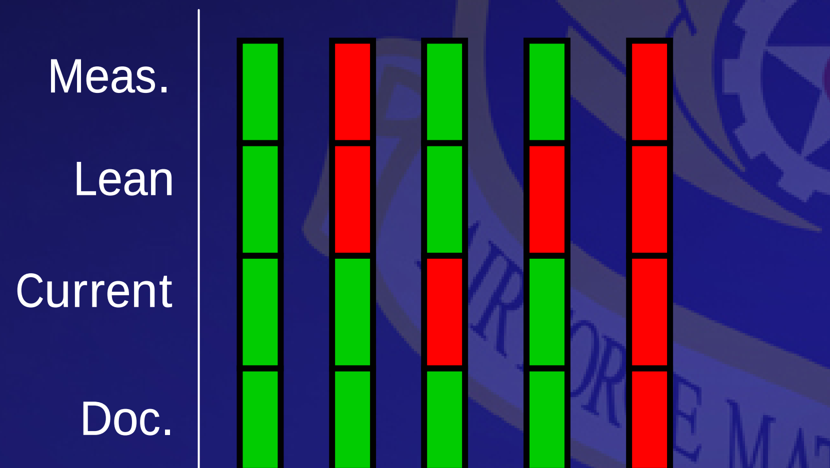
Phase 4: Identify and Define Processes



Requirements

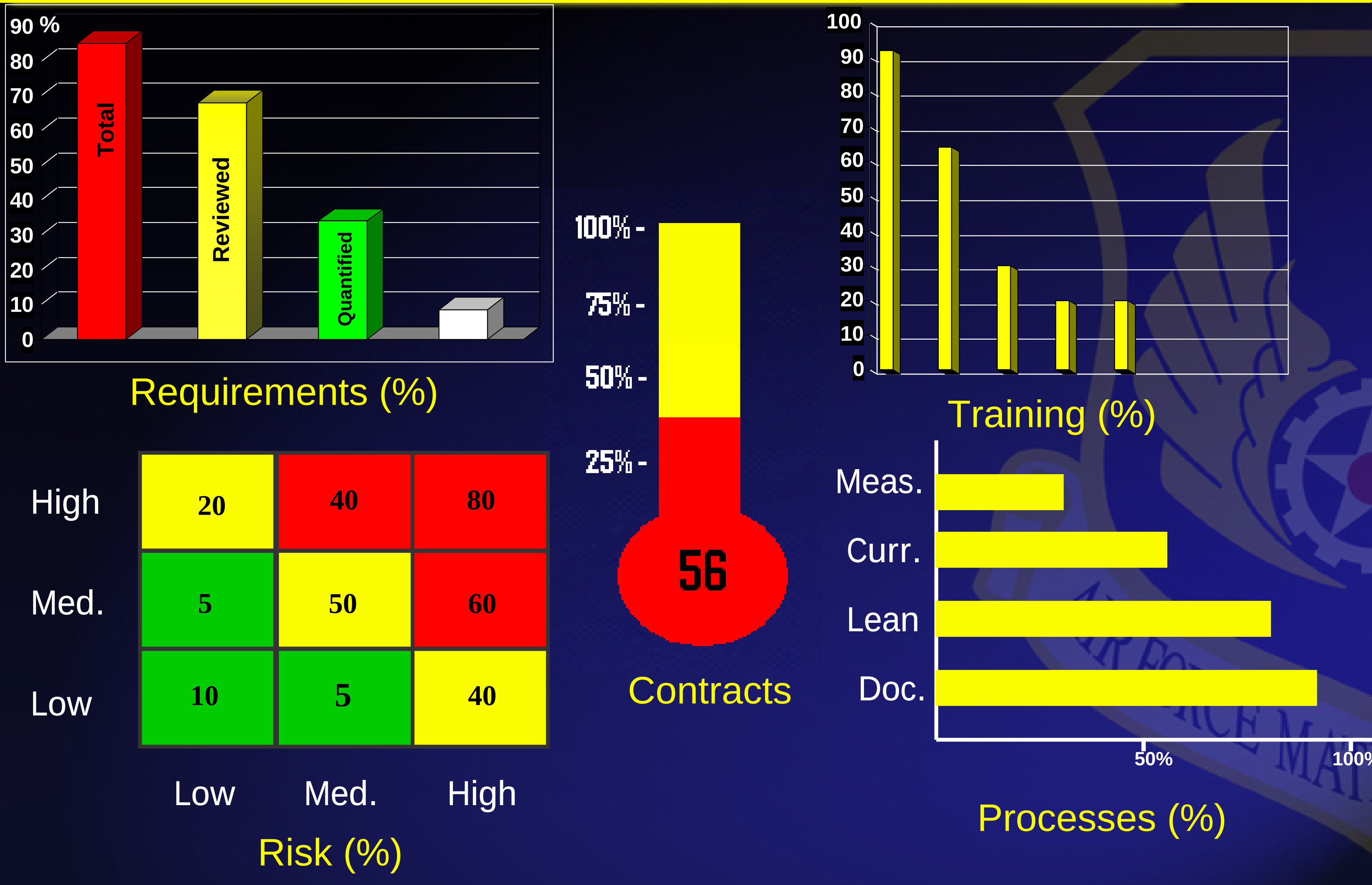
	Low	Med.	High
High	0	2/4	1/2
Med.	1/6	0/1	3/4
Low	1/3	2/4	2/3

Risk

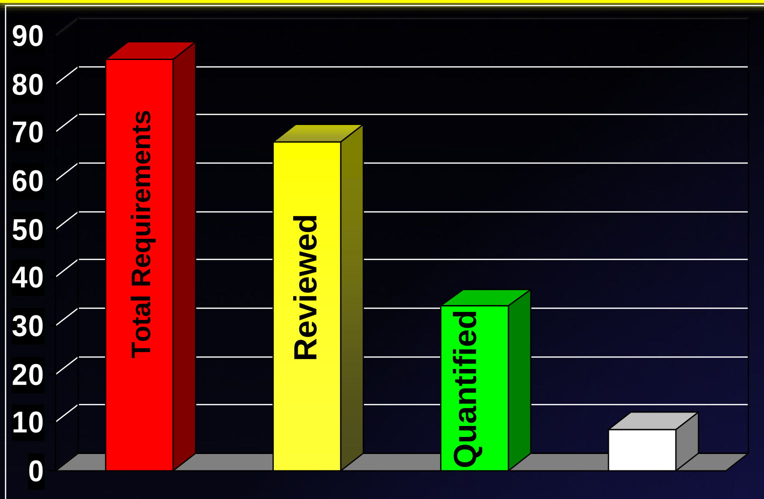


Processes

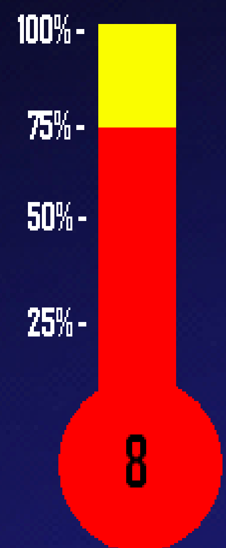
Sample Organization Sys Eng "Dashboard"



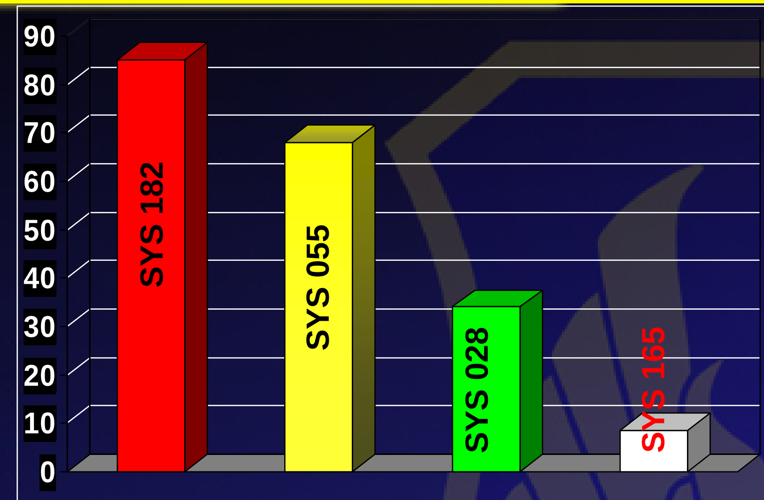
Sample Program Sys Eng "Dashboard"



Requirements



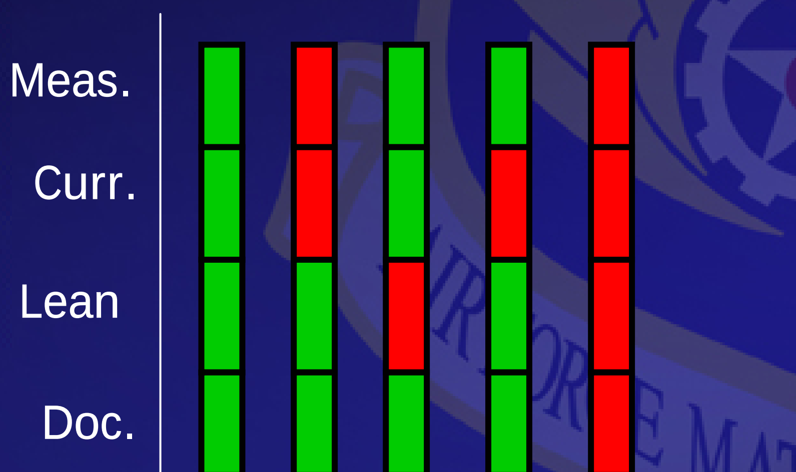
Contracts



Training

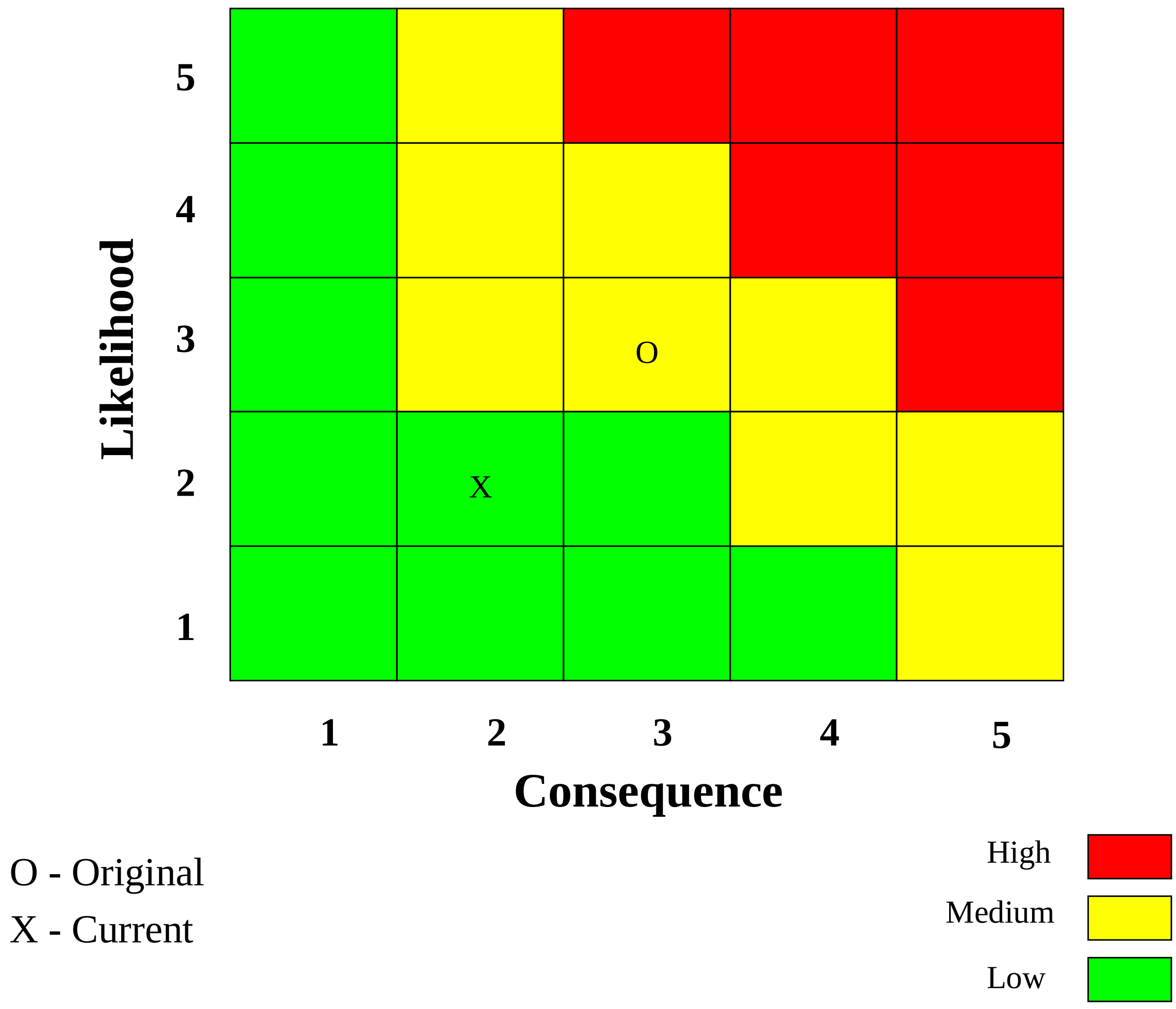
	Low	Med.	High
High	0	2/4	1/2
Med.	1/6	0/1	3/4
Low	1/3	2/4	2/3

Risk

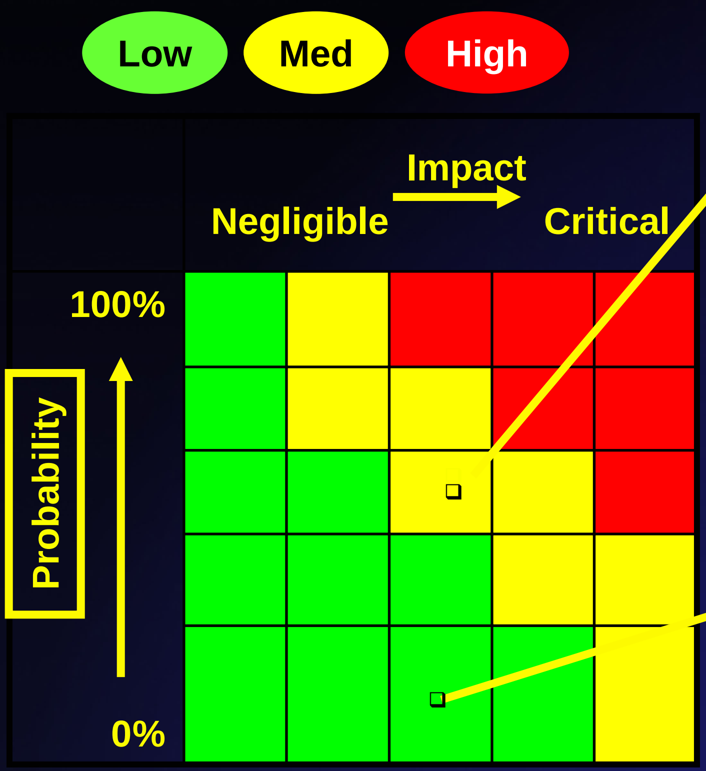


Processes

Risk Assessment Matrix



Technical Risk #2



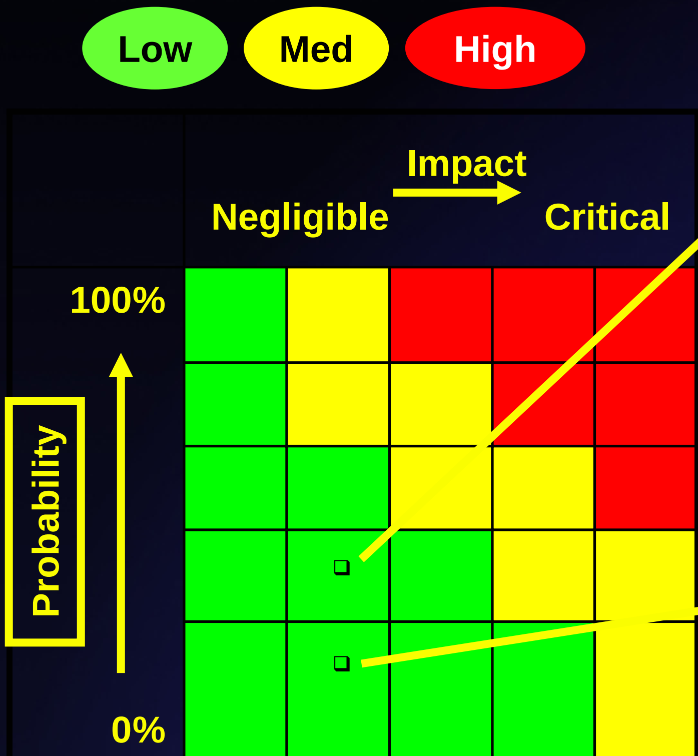
Technical Risk: If contractor fails to adequately perform systems engineering then modifications and upgrades could be impacted/delayed.

Mitigation Plan:

- Contractor has Quality Assurance Plan and Program Management Plan on current contract. Plans will be updated for new contract
- Government will require contractor to submit requirements correlations matrix (RCM) for modification/upgrade efforts
- Government will require contractor to use an approved risk management program for modification/upgrade efforts
- Government will follow disciplined requirement matrix process outlined in 727 ACSG O.I. to prevent unplanned requirements/complexity increases & track via established metrics

Risk Workshop Completed – 14 Mar 07

Technical Risk #3



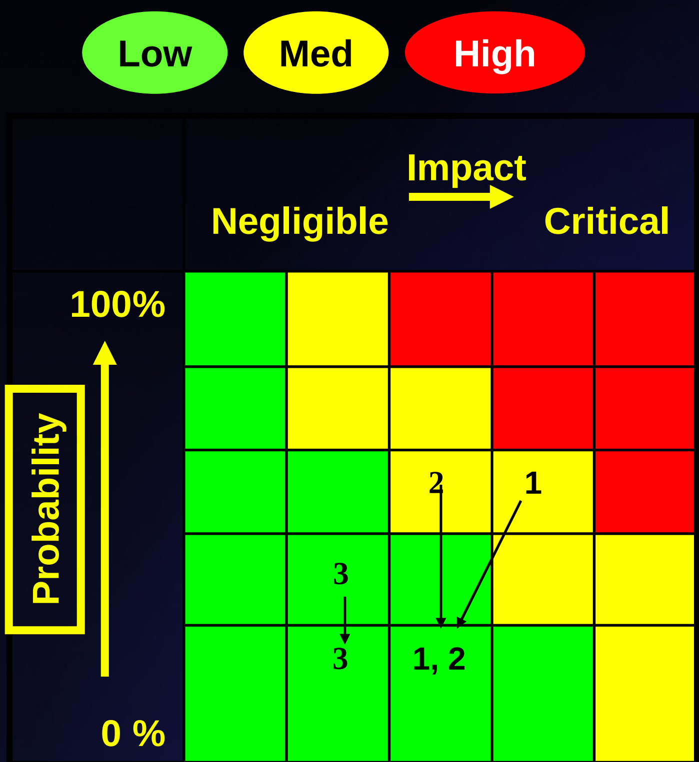
Risk Workshop Completed – 14 Mar 07

<u>Technical Risk:</u> **If configuration management for communication equipment is not maintained then system interoperability could be hindered.**

<u>Mitigation Plan:</u>

- **Government will require current contractor configuration management plan will be updated for new contract**
- **SPO will work with users and contractor to ensure regular configuration inventories are occurring to ensure configuration reports are accurate**
- **Government will conduct test planning criteria and resource requirements at the start to minimize potential interoperability conflicts and/or oversights**

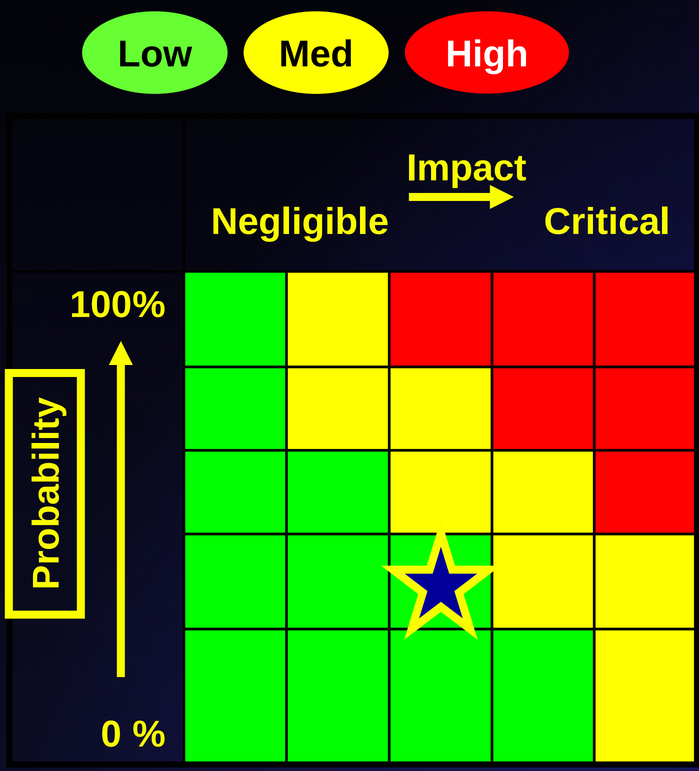
Technical Risk Summary



OVERALL TECHNICAL RISK IS LOW

Risk Workshop Completed – 14 Mar 07

Program Risk Summary



Risk Workshop Completed – 14 Mar 07

Program Risk: Five (5) Cost and three (3) Technical risks have been identified

Mitigation Plan:

- Mitigation plans have been put into practice for all identified risks

OVERALL PROGRAM RISK IS LOW

Tracking Progress via Metrics

- ✓ **Metrics developed to track progress**
- ✓ **Metrics shown regularly to upper management**
  - ❑ **1st staff meeting of month**
  - ❑ **Quarterly Weapon System Reviews**
  - ✓ **Metrics must be able to roll up**
- ✓ **Metrics will track:**
  - ✓ **Systems Engineering Implementation**
  - ✓ **Requirements**
  - ✓ **Risk**
  - ✓ **Processes**
  - ✓ **Training**
  - ✓ **Contracts**

Applying Systems Engineering during Pre-Acquisition Activities

NDIA 10th Annual
Systems Engineering Division Conference
San Diego, CA
23 October 2007

Jeff Loren
MTC Technologies, Inc.
(SAF/AQRE)

Outline

- Need for Early SE
- Defining Early SE
- SMC Pilot Program
- Policy Initiatives
- Challenges
- Way Forward

Why?

"Systems Engineering is broken; go fix it."

Attributed to SecAF James Roche, spring 2002

Lack of systems engineering has been cited as the cause of major defense acquisition program failures

Cost overruns, schedule slips, mishaps, external criticism, instability in requirements and funding, poor acquisition strategies

The Need

- **RAND Project Air Force study: "Is Weapon System Cost Growth Increasing?"**

  "… despite the many acquisition reforms and other DoD management initiatives over the years, the development cost growth of military systems has not been reduced."*

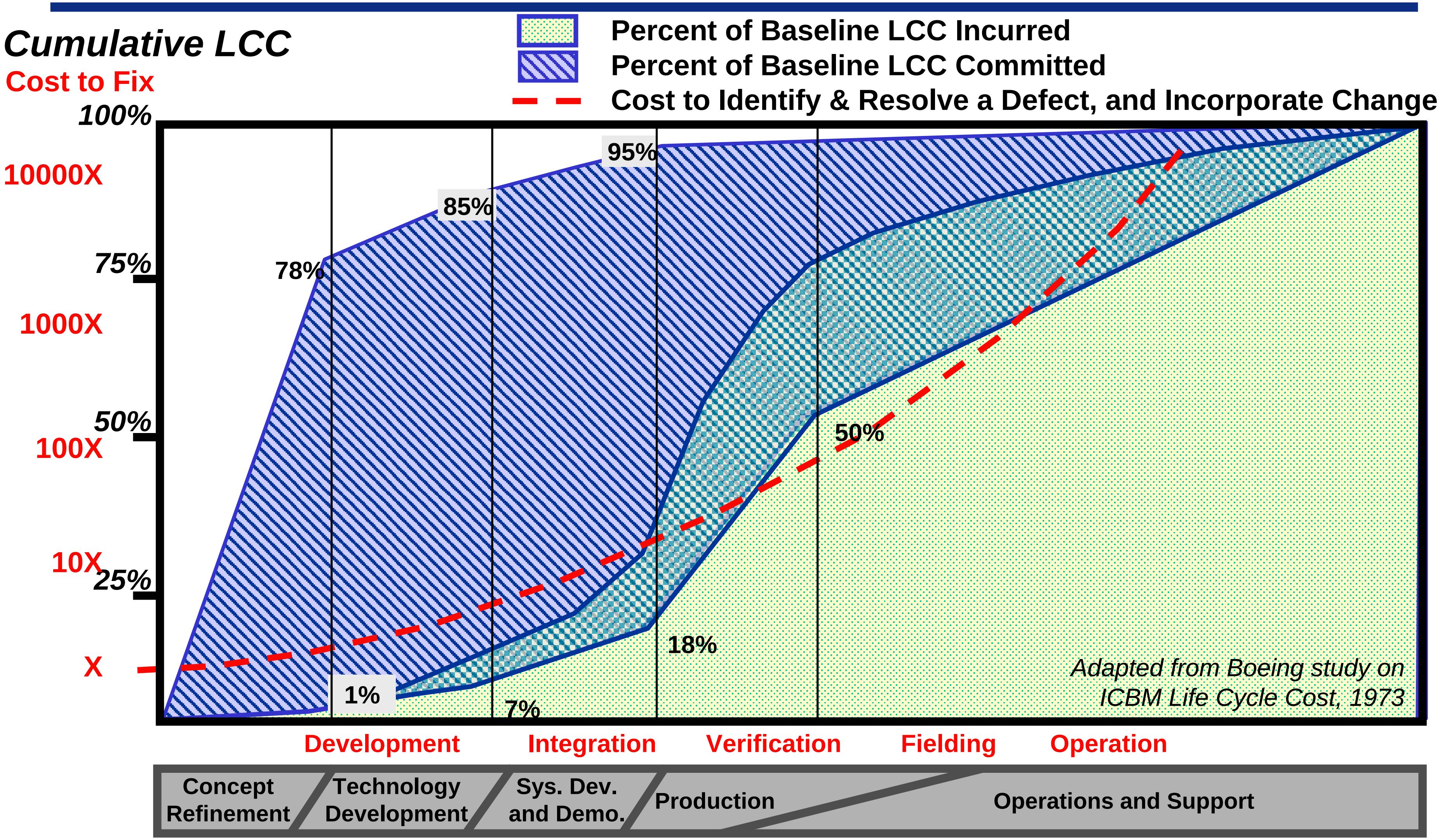
- **This, however, does not indicate we are necessarily doing badly …**

  "There is no doubt that the systems developed in each successive decade are more complex than those of the prior decade. The ever-increasing complexity of technology, software density, system integration complexity, and the like make estimating a total system's development cost … an ever-increasingly challenging endeavor."*

- **Increasing complexity has kept stride with increasingly improved acquisition**

* *Is Weapon System Cost Growth Increasing*, 2007, RAND

Why It's Needed -- Early Decisions Are Key Life Cycle Cost Drivers



Defining Early SE

- **What it is:**
  - **The systems engineering (SE) tie between JCIDS and the AoA … and beyond**
  - **A disciplined process for scoping capability needs and developing concepts**
  - **The process required to do the necessary work for a successful AoA**
  - **A means to identify candidate technologies and assess the realism for transition**
  - **An actual pre-acquisition effort**
- **What it is *not*:**
  - **An AoA**
  - **"Gaming the system" to favor a solution**

Pre-Acquisition "Systems Thinking"
Boundary Conditions

Pre-Acquisition SE efforts, like those throughout the rest of the life cycle, are essentially an "integrating function"

- **Pre-A SE mainly occurs in two domains, each with set boundaries**
  - **The first SE domain spans the period from JCIDS initiation of a need to AoA entrance:**

$$\int_{\text{JCIDS}}^{\text{AoA Entrance}} F_1(SE)\,dSE$$

  - **The second domain continues the SE functions after the AoA until formal program handoff:**

$$\int_{\text{AoA Exit}}^{\text{Program Initiation}} F_2(SE)\,dSE$$

- **The SE functions in both domains are fundamentally similar, but there are attributes unique to each**

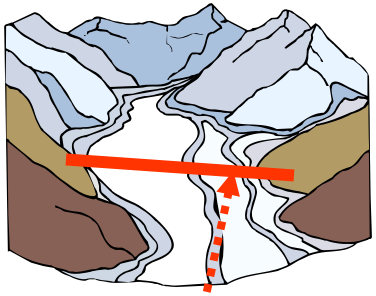
Pre-Acquisition Example

Capability need: "Get people and equipment across a body of water"

- **First pass asks key questions:**
  - **What does "water" mean? (Solution sets will be very different for Piscataway Creek, the Potomac River, and the Pacific Ocean.)**
  - **Are there any obvious constraints? (Sensitivity to water exposure? Time-in-transit limitations?)**
- **Initial analysis should yield various methods, and a cost / risk summary for each**
  - **Airlift**
  - **Bridge**
  - **Catapult (unsuitable for people)**
  - **Drive across (depends on depth, current, etc.)**
  - **Drive around (depends on total distance, thus time)**
  - **Ferry**
  - **Helicopter**
  - **Tunnel**
- **Analysts should also be able to quickly rule out candidates that don't meet constraints**

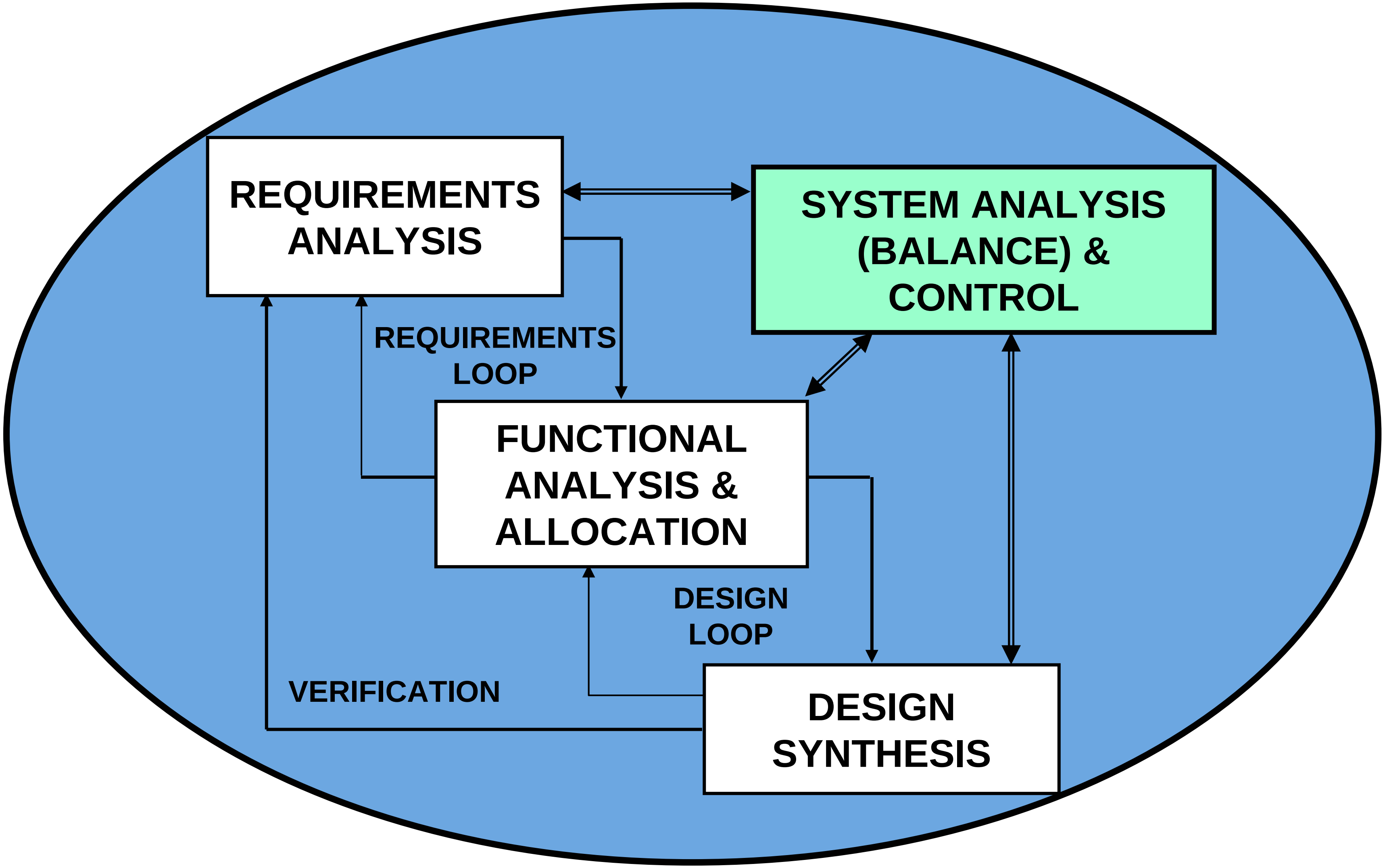
Pre-Acquisition Example (cont)

- Parametric trades within a method (bridge, tunnel, etc.) consider how relevant factors (depth, width, current, etc.) affect a baseline candidate solution
  - "A mile upstream the channel is narrower. The shorter span means ~30% less material cost, but road access and construction staging are difficult."
  - "A mile downstream the current is slower. The longer span means ~20% more material cost, but you can complete construction earlier."

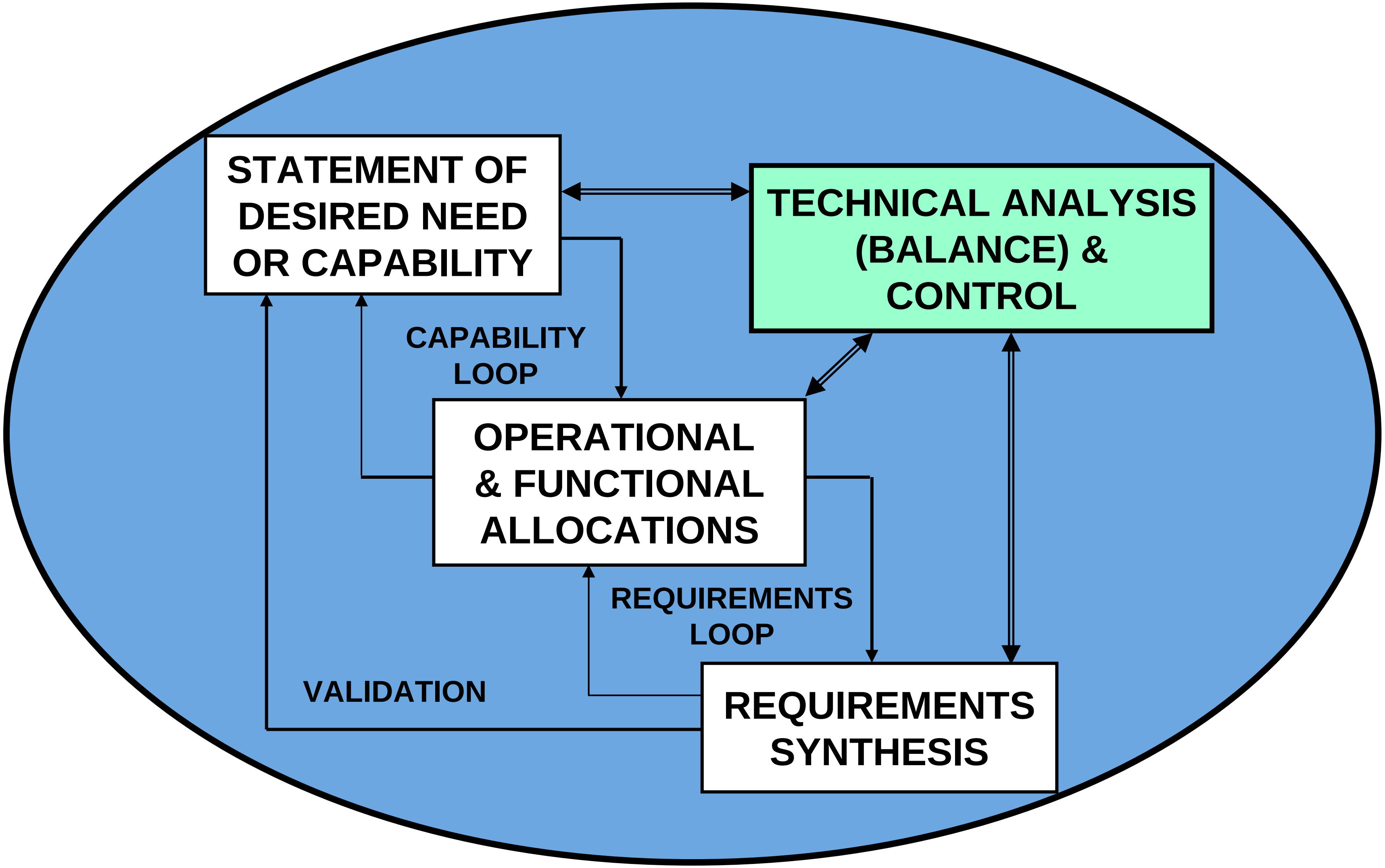


- Once the AoA looks at families of candidates and concludes that a bridge is the best solution, a similar process is employed to determine the optimum type (cantilever, suspension, pontoon, single- or two-span draw, etc.)
- Pre-AoA measures are high-level programmatic / operational parameters (cost, schedule, vehicle capacity, etc.)
- Post-AoA measures have a more traditional design and execution focus (EVM, weight, material durability, etc.)

SE Applied to a Product or System
Transforming Requirements to Design



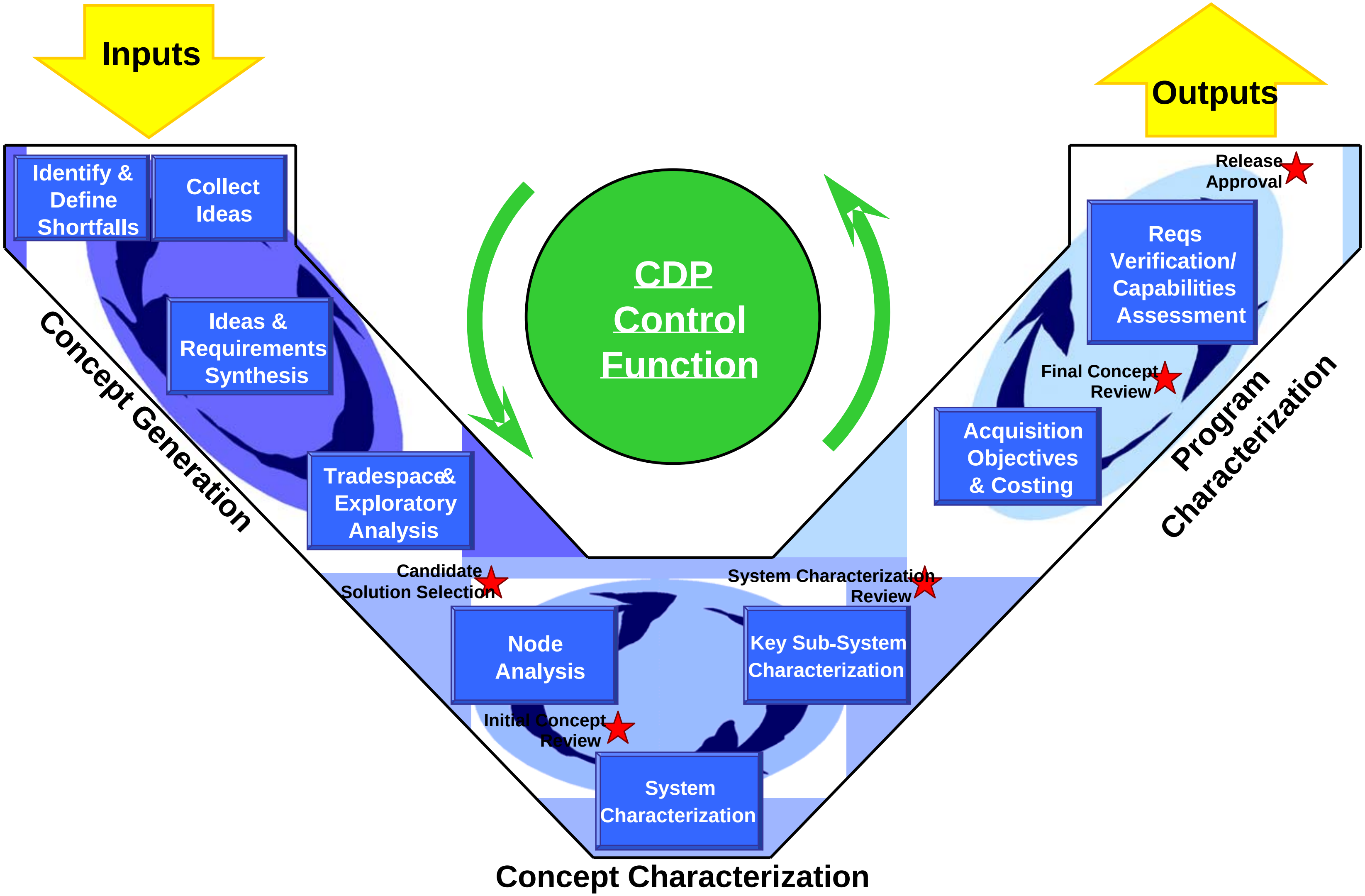
SE Applied to a Capability
"Requirements Engineering"



SMC Pilot Program

- Modeled after test case developed for a relatively cheap, ill-defined launcher
- Study commissioned by SAF/AQR
  - Objective: Develop and validate a concept development systems engineering process & guide
  - Identify barriers to success in concept development
- Used standard systems engineering tenets as a baseline
- Modified for future concept development efforts
- Currently validating and documenting

SMC Concept Development Process V-Chart



Integrity - Service - Excellence

NRC Pre-A SE Study

Co-Chairs: Dr Kaminski, Gen (ret) Lyles

TASKS

- Assess the contribution of pre-A SE on Air Force programs
- Determine level of pre-A SE required for program success
- Determine current barriers to pre-A implementation, both on concepts leading to an AoA and for the post-AoA selected alternative(s)
- Develop a framework/methodology for developmental organizations to ensure proper pre-A SE is accomplished
- Recommend changes to enable adequate pre-A SE, and the means for seamless transition from need identification through program office standup

STATUS

- Study committee received approx 30 formal briefings
- Committee members currently conducting analyses and writing assigned sections of report
- Anticipate start of peer review Jun 07
- Public release of final report anticipated Nov 07

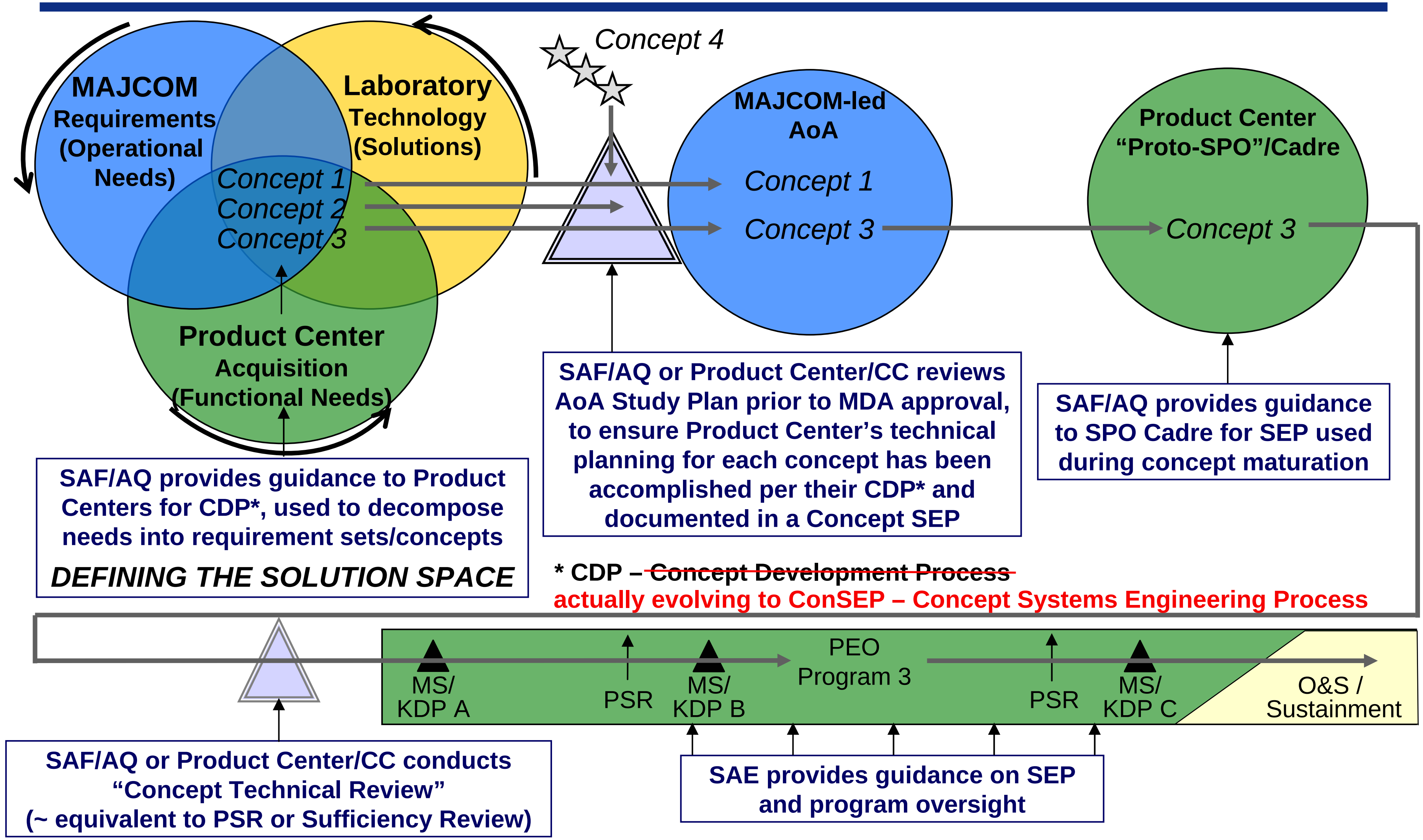
AF Early SE Policy Initiatives

"Nothing in the world is more important than policy!" *

- "Fixing" SE in the pre-Acquisition world requires a two-pronged approach
  - Acquisition policy -- DoD 5000.2, 63 series AFIs
  - Requirements policy -- JCIDS, AFI 10-601
- Current policies *encourage* acquisition and requirements to coordinate, but do not have hooks to *force* working together
- Islands of success exist, but tend to be personality/ experience driven
- Opportunities exist to slip early acquisition community SE involvement into the requirements process

** Lt Col Mark Wilson, Policy Branch Chief, 19 Oct 07*

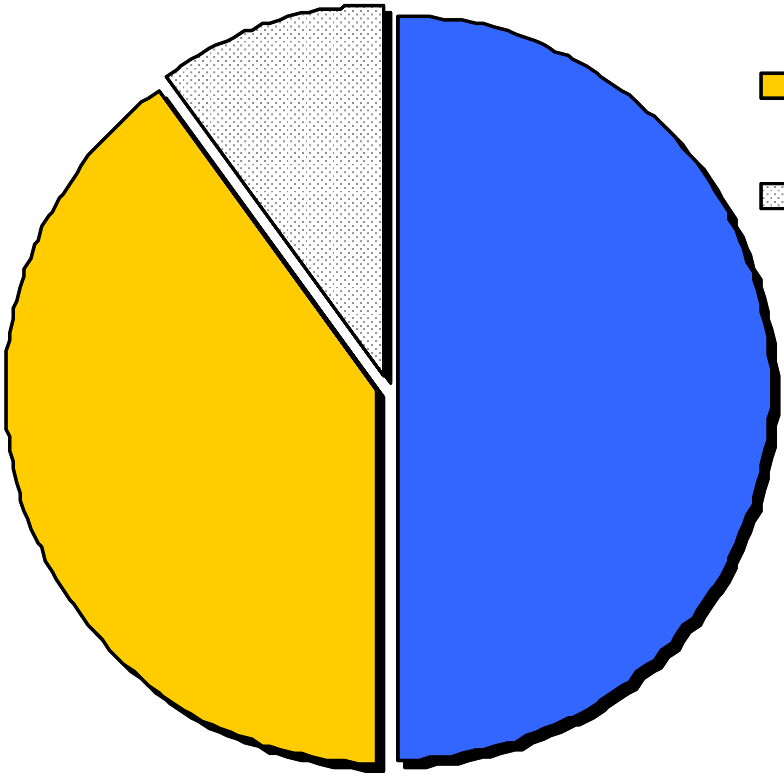
SE and Technical Planning in Pre-Program Concept Development



Challenges

- Begins with a “R”, rhymes with “forces”
  - Experience “bathtub” (lots of folks with <5 or >20 years, not much in between)
  - Not a very deep bathtub
- Minimize project- and personality-dependent MAJCOM/ COCOM coordination
  - Field users drive most pre-A capability definition efforts in all four domains (air, space, weapons, C2)
  - User community for C2 products is very IT-savvy; things in the IT world tend to happen very quickly
  - Immediate solutions preferred over rigorous process
- Understanding of architecture/SoS concerns
  - Scope is somewhat dependent on domain (more significant for space and C2, less so for aircraft and weapons)
  - Frequent unintended life cycle consequences of “IT now”
- On the plus side, early SE is not broken -- our people are excellent at what they do
  - Above challenges dilute effectiveness

Program Success Factors
(it ain't all SE's fault!)



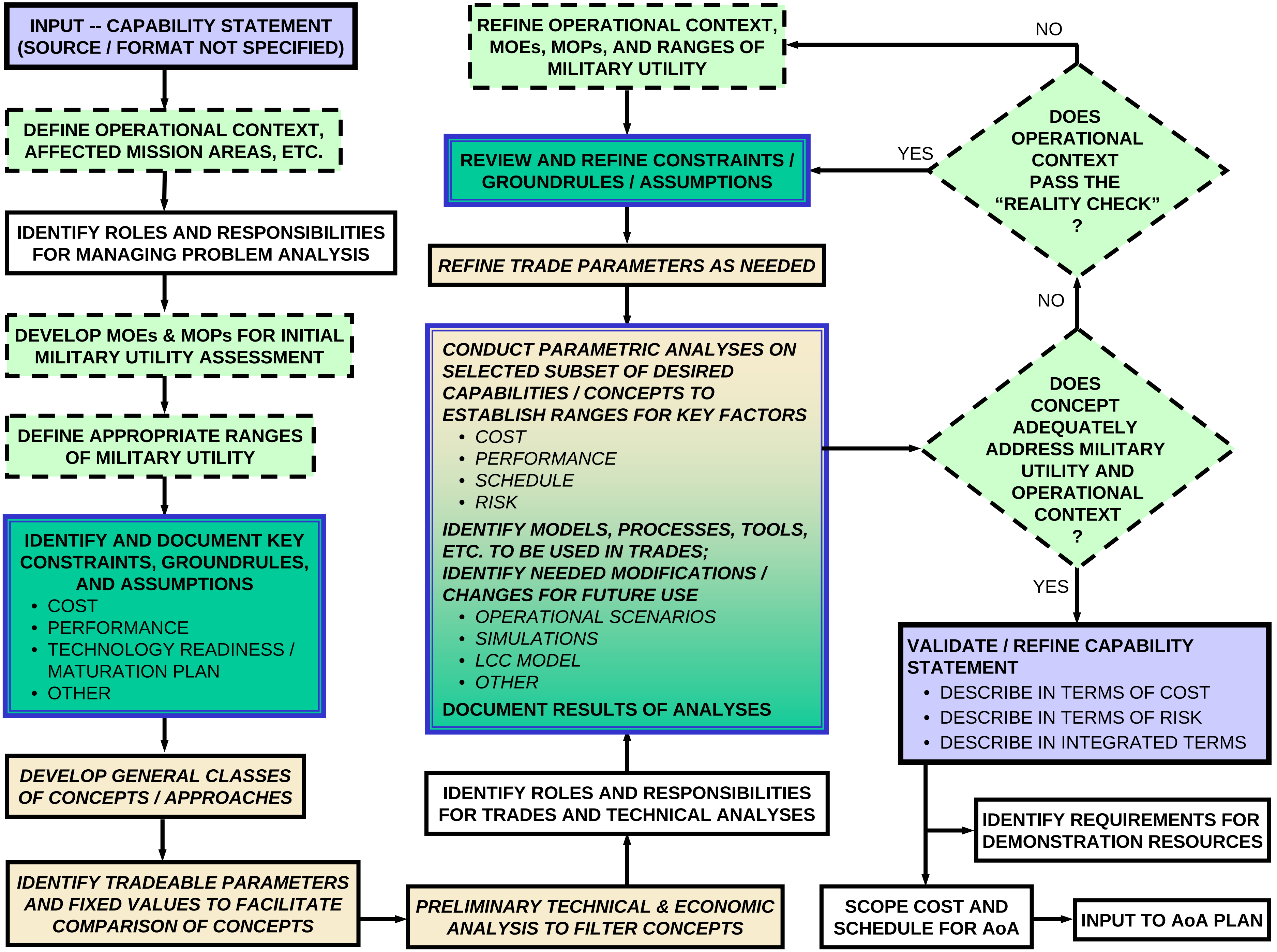
- **"50% Politics" translates to**
  "Nothing happens without an acceptable political compromise"
- **"40% Budget" … pretty much a fact of life**
- **"10% Technical & Operational Analysis" can appropriately inform (and influence) the other 90% of the trade space**
  - ***If* the right team is engaging with the broader stakeholder community**
  - ***If* those community members are sufficiently objective**
- **Concept Development personnel/ organizations must be politically astute**

Courtesy Chris Leak, ASC/XRS

Way Forward

- Complete SMC, ASC pilot programs
- Socialize draft policy/guidebook throughout AF product centers (in progress)
- Develop forum for 4 product center CD shops to meet/exchange ideas, tools, personnel
- Create more stable funding environment for CD efforts
- Continuing working with OSD and AF Requirements communities on incorporating early SE into broader policy

Backup


INPUT -- CAPABILITY STATEMENT (SOURCE / FORMAT NOT SPECIFIED)
DEFINE OPERATIONAL CONTEXT, AFFECTED MISSION AREAS, ETC.
IDENTIFY ROLES AND RESPONSIBILITIES FOR MANAGING PROBLEM ANALYSIS
DEVELOP MOEs & MOPs FOR INITIAL MILITARY UTILITY ASSESSMENT
DEFINE APPROPRIATE RANGES OF MILITARY UTILITY
IDENTIFY AND DOCUMENT KEY CONSTRAINTS, GROUNDRULES, AND ASSUMPTIONS
• COST
• PERFORMANCE
• TECHNOLOGY READINESS / MATURATION PLAN
• OTHER
DEVELOP GENERAL CLASSES OF CONCEPTS / APPROACHES
IDENTIFY TRADEABLE PARAMETERS AND FIXED VALUES TO FACILITATE COMPARISON OF CONCEPTS
PRELIMINARY TECHNICAL & ECONOMIC ANALYSIS TO FILTER CONCEPTS
IDENTIFY ROLES AND RESPONSIBILITIES FOR TRADES AND TECHNICAL ANALYSES
CONDUCT PARAMETRIC ANALYSES ON SELECTED SUBSET OF DESIRED CAPABILITIES / CONCEPTS TO ESTABLISH RANGES FOR KEY FACTORS
• COST
• PERFORMANCE
• SCHEDULE
• RISK
IDENTIFY MODELS, PROCESSES, TOOLS, ETC. TO BE USED IN TRADES; IDENTIFY NEEDED MODIFICATIONS / CHANGES FOR FUTURE USE
• OPERATIONAL SCENARIOS
• SIMULATIONS
• LCC MODEL
• OTHER
DOCUMENT RESULTS OF ANALYSES
DOES CONCEPT ADEQUATELY ADDRESS MILITARY UTILITY AND OPERATIONAL CONTEXT ?
NO
YES
DOES OPERATIONAL CONTEXT PASS THE “REALITY CHECK” ?
NO
YES
REFINE OPERATIONAL CONTEXT, MOEs, MOPs, AND RANGES OF MILITARY UTILITY
REVIEW AND REFINE CONSTRAINTS / GROUNDRULES / ASSUMPTIONS
REFINE TRADE PARAMETERS AS NEEDED
VALIDATE / REFINE CAPABILITY STATEMENT
• DESCRIBE IN TERMS OF COST
• DESCRIBE IN TERMS OF RISK
• DESCRIBE IN INTEGRATED TERMS
IDENTIFY REQUIREMENTS FOR DEMONSTRATION RESOURCES
SCOPE COST AND SCHEDULE FOR AoA
INPUT TO AoA PLAN

Simplifying & Scaling Engineering Processes: Unifying Business Units and Engineering Disciplines

A Lean Engineering Journey

Rockwell Collins

A New Order of Things

- And it ought to be remembered that there is nothing more difficult to take in hand, more perilous to conduct, or more uncertain in its success, than to take the lead in the introduction of a new order of things.
- Because the innovator has for enemies all those who have done well under the old conditions, and lukewarm defenders in those who may do well under the new.
- This coolness arises partly from fear of the opponents, who have the laws on their side, and partly from the incredulity of men, who do not readily believe in new things until they have had a long experience of them.
- Thus it happens that whenever those who are hostile have the opportunity to attack they do it like partisans, whilst the others defend lukewarmly…

- Nicolo Machiavelli, written circa 1505, published 1515

Objectives

- Understand basic & historical evolution of RCI engineering processes
- Understand steps through process transformation
- Explore outcomes from transformation
- Explore expected resulting behavior

Previous State to 2000

- Rockwell Collins consisted primarily of 3 distinct business units
  - Government Systems
    - Primary customers: military aerospace
    - Process basis: MIL-STD-499, DoD-STD-2167
    - Documented process: Engineering Project Manual – largely hardware development
  - Business & Regional Systems
    - Primary customers: business jets, small regional transports, FAA
    - Process basis: FAA certification (RTCA DO-178)
    - Documented process: Systems Engineering Process – closely aligned with FAA expectations and avionics application
  - Air Transport Systems
    - Primary customers: large transports, passenger & cargo
    - Process basis: Aircraft OEM Processes
    - Documented process: Loose collection of process papers; OEM-driven process

Reformation

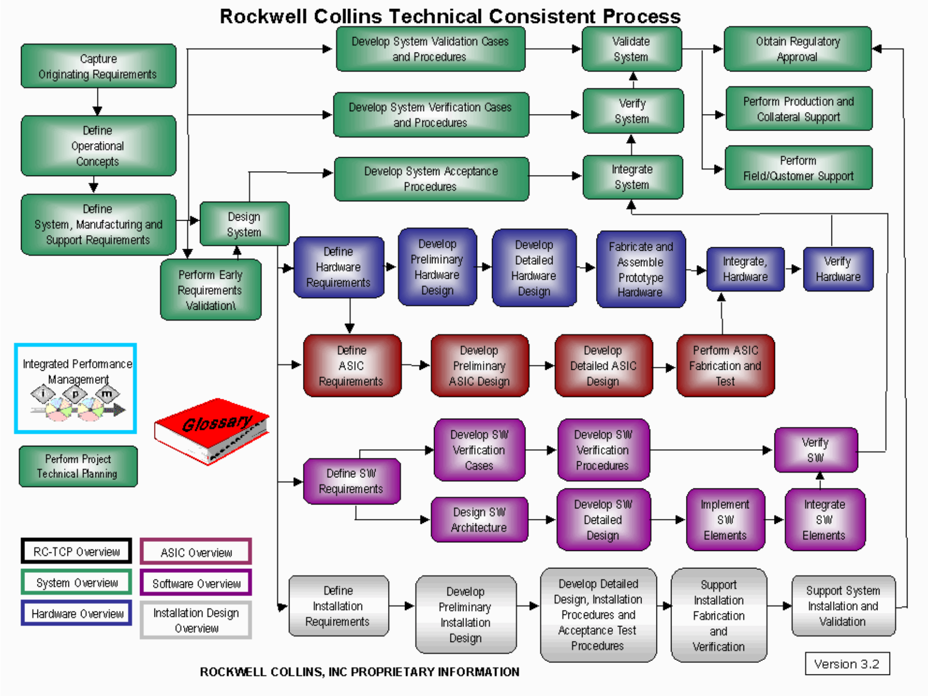
- Enterprise use of SAP
  - New financial and order administration capability
  - How does engineering align with SAP?

- Cross- Business Unit Functional Teams
  - Process & Practioner views of new process
  - Cross-Business Teams Aligned along functional boundaries
    - Systems Engineering
    - Software Engineering
    - Hardware Engineering (Electrical & Mechanical)
    - ASIC Engineering
    - Installation (latecomer)

Consistent Process Model: First Steps

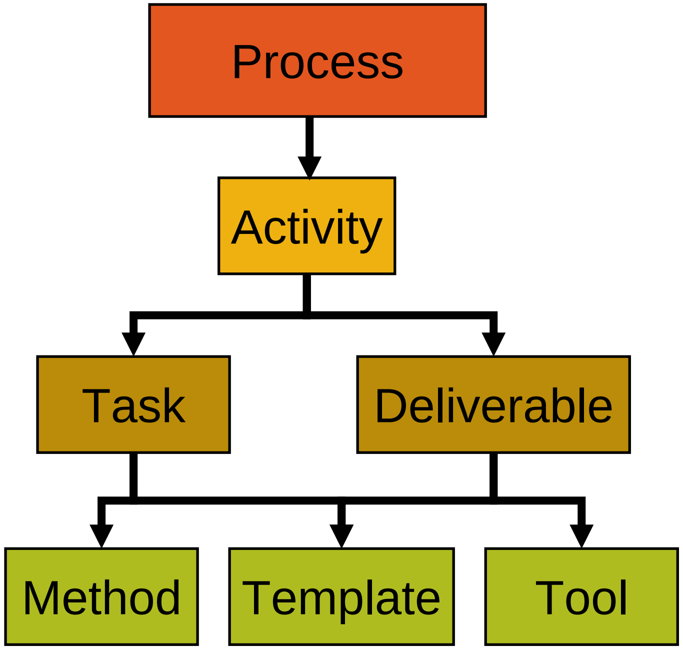
- Technical Consistent Process (TCP) v1.0 model released in 2000
  - Align business units under one process
  - Align engineering process for use with SAP

- TCP interactive web-site
- TCP tailoring worksheet
- TCP computer-based training



Resulting Behaviors

- Discipline-Centric views of “Engineering”
  - Inconsistencies between disciplines – similar, yet different
  - Depth vs. breadth of process content
  - Activity vs Phase Models
- Disparate Application of Process
  - “Process Tax”
- Evolving Process Library
- Potential Consistent Metrics



Evolving the TCP: Current Steps

- Design & Development (D&D) Cycle Time Reduction (CTR) Initiative
  - Simplify the engineering process model
    - Eliminate redundancy
    - Remove inconsistencies
  - Improve scalability
  - Improve user friendliness and information understanding
  - Maximize reuse of existing TCP

Observations

- Scalability
  - Consider TurboTax approach to process tailoring
    - Project & product characteristics drive process needs
  - Allow common process model
    - Shared by business units
    - Shared between disciplines

- Initial
  - Cross- Business Unit Functional Teams
    - Aligned along same discipline-centric approach
    - Allowed functional practitioners voice to express desires to reform TCP
- Synthesize observations into ONE process model
- Subsequent
  - Mixed functional teams
    - Systems, software, hardware, ASIC from different business areas collaborate
    - Attempt to unify a single engineering process model
    - 90+ practitioners and process experts – meet in smaller groups of 10-20 participants

Lean Engineering: Simplify & Eliminate

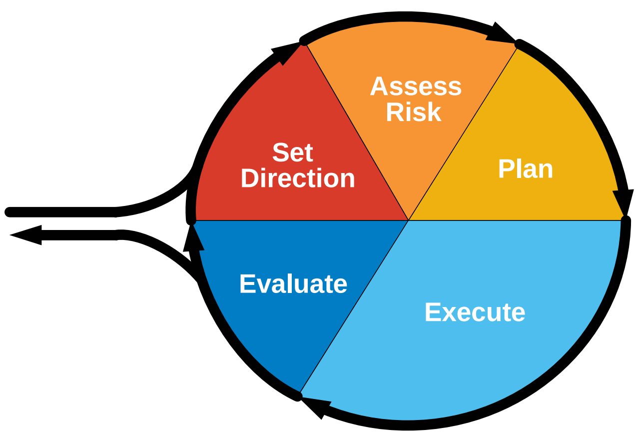
- Unified disciplines under one process model
  - Eliminate inconsistencies between disciplines
  - Remove redundancy
  - Simplified process model

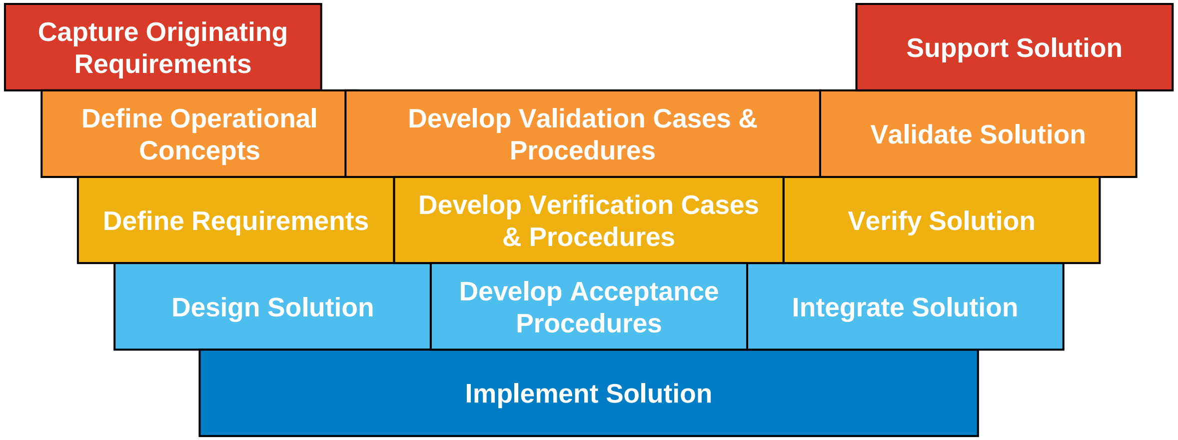
TCP	Original	New	% Total Reduction
Activities	39	18	54%
Tasks	344	129	63%

Technical Consistent Process v4.0

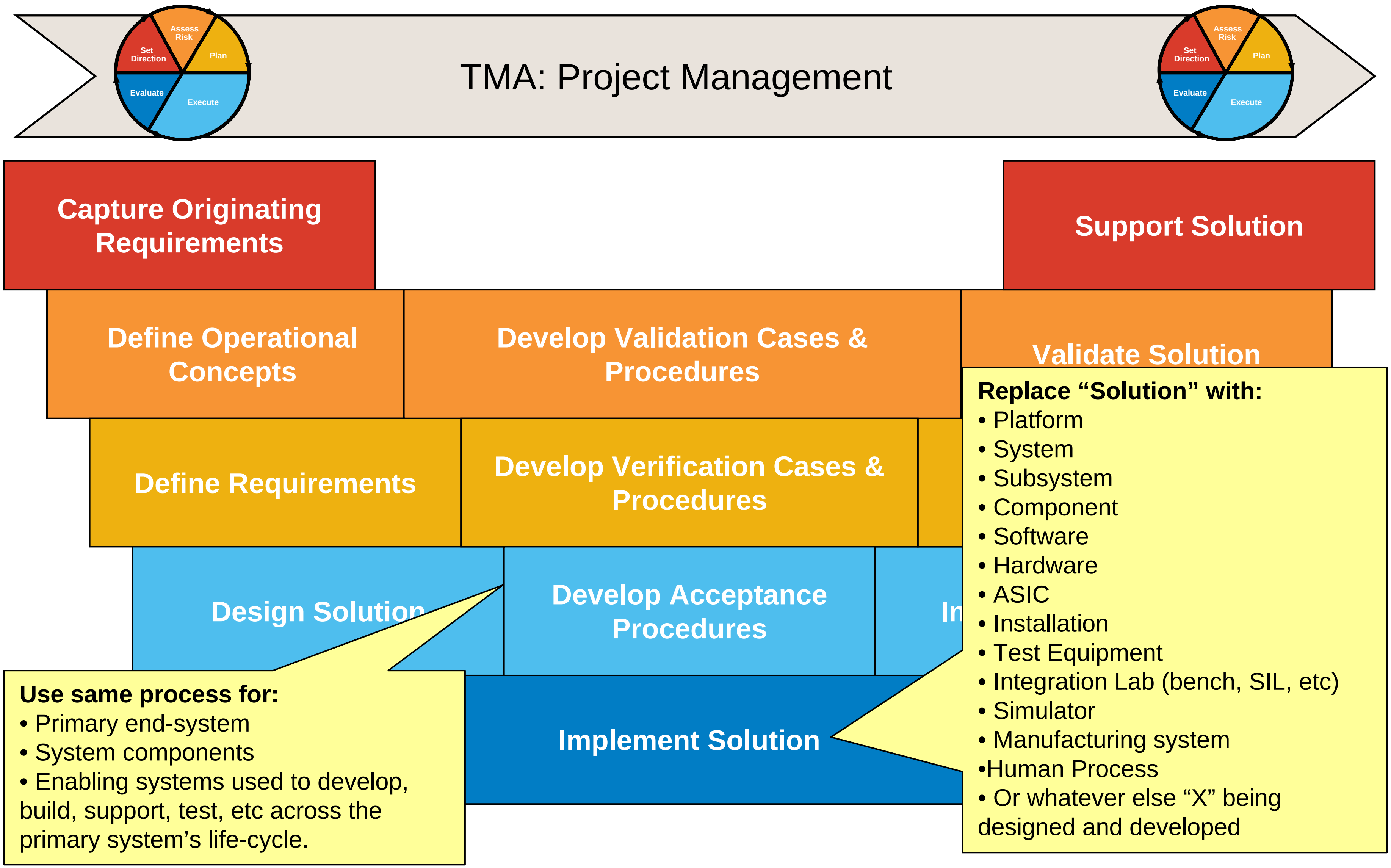
Technical Management Activities (TMA)

Technical Development Activities (TDA)



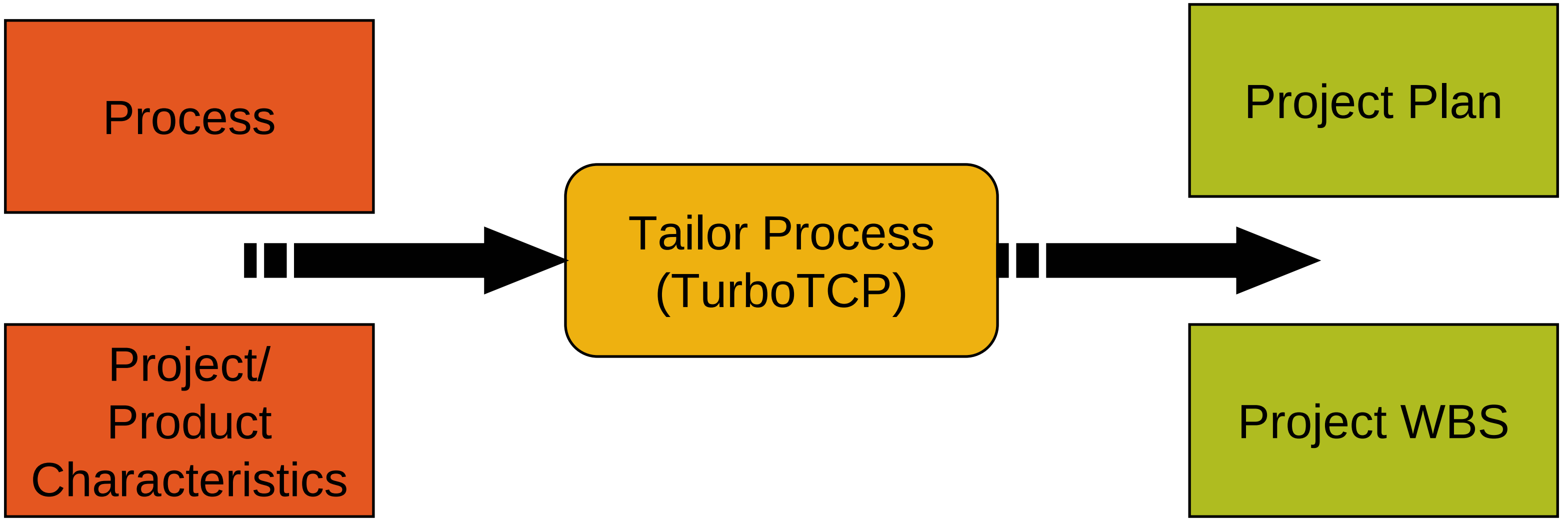


Instantiable Process Model



Expected Behaviors

- Process forms the basis of project planning



- Consistent metrics
- Consistent application

Rockwell Collins

Conclusion

- Understand basic & historical evolution of RCI engineering processes
  - Business unit & discipline centric processes evolving to unified, tailorable engineering process model
- Understand steps through process transformation
  - Collaborative teams – practitioners and process experts
- Explore outcomes from transformation
  - Scalable process framework
- Explore expected resulting behavior
  - Process provides basis for planning & execution

Integrating Engineering Project Management and Product Development Processes

A Lean Engineering Journey

Objectives

- Understand context of RCI engineering process evolution
- Understand roles & responsibilities of project managers within RCI culture
- Explore the relationship of project management to product development processes
- Explore the roles of systems engineering vs. project management

Evolving Processes: Current Steps

- Design & Development (D&D) Cycle Time Reduction (CTR) Initiative
  - Simplify the engineering process model
    - Eliminate redundancy
    - Remove inconsistencies
  - Improve scalability
  - Improve user friendliness and information understanding
  - Maximize reuse of existing engineering process
    - Technical Consistent Process (TCP)

Problem Realization

- TCP Primary Focus: Engineering Development
  - Typical V-Model approach to engineering
  - Failed to address Project Management

- How does scalability of the process address Project Management scalability?
- How should Project Management fit with the engineering design & development process?

Project Manager Definitions

- Life Cycle Value Stream Manager (LCVSM)

also known as Program Manager or Product Line Manager

  - Life Cycle Responsibility for products.
  - This includes business pursuit and capture, product development, transition to production, customer delivery and support, and transition out of production.
  - Must coordinate activities across the RCI-aligned business model; Engineering, Manufacturing, Marketing, Sales, and Service functions.

also known as Technical Director

- Technical Project Manager (TPM)
  - Single point of contact for engineering on a development project.
  - Responsible for the technical leadership and project management of the design & development activities, within the guidelines set by the LCVSM/Program Manager and Customer.
  - Provides project management expertise by planning, organizing, directing, and coordinating functional department activities to achieve cost, schedule, and performance requirements

- Project Engineer (PE)
  - Lead engineer assigned to a specific project to represent the

Engineering Leadership: Common Purpose, Different Roles

Project Management

LCVSM ⟷ TPM ⟷ PE

LCVSM

- Multi-Disciplinary Team Leader
  - Operations, Services, Finance, Engineering
- Responsible for Profit & Loss
- Responsible for overall project commitments
- High Customer Contact
  - Business Development
  - Enterprise Coordination
- Covers project activities for DP A → DP G

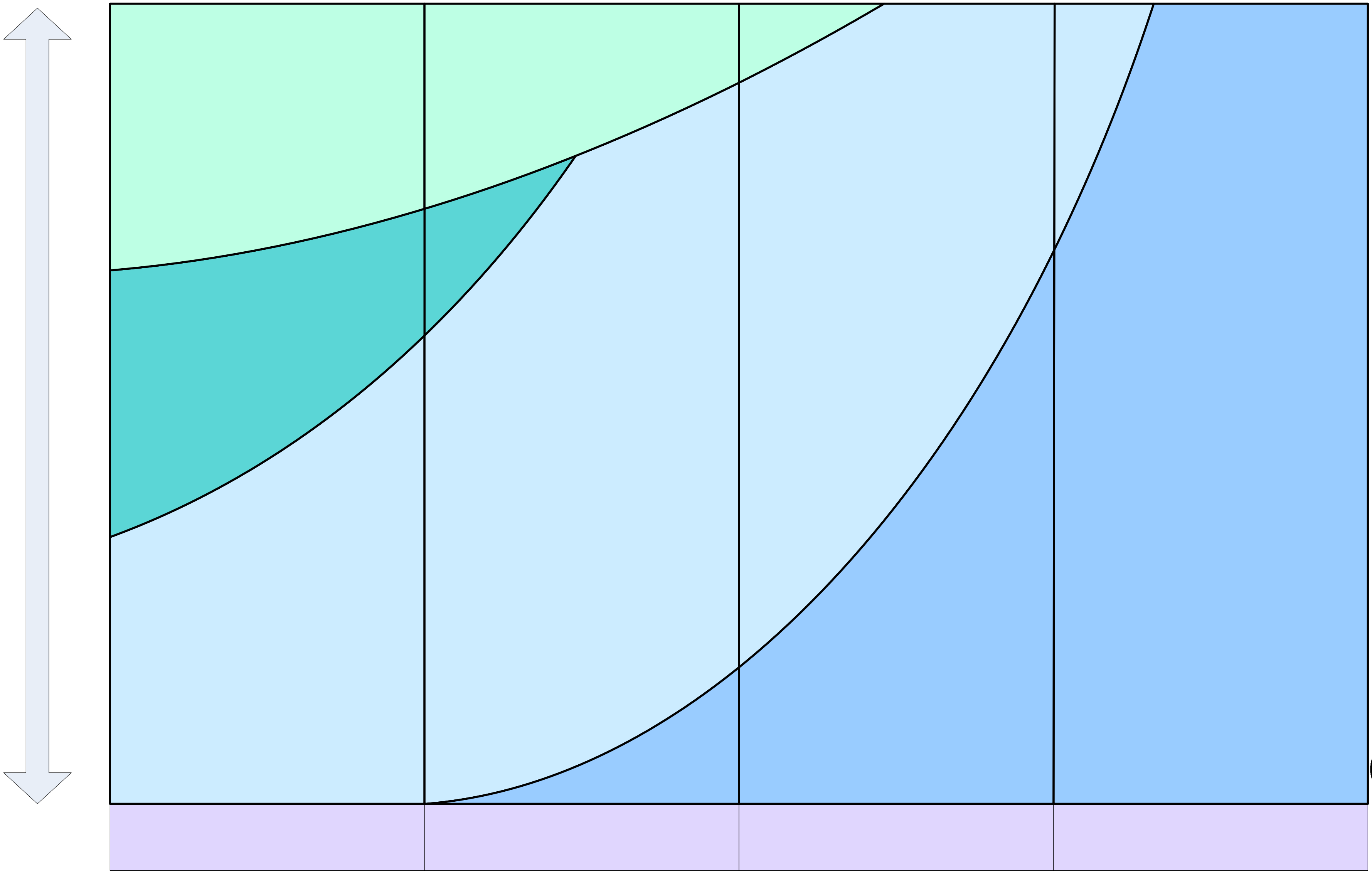
TPM

- Multi-Disciplinary Engineering Team Leader
  - Systems, Software, Electrical, Mechanical, Quality
- Responsible for Technical Project Budget
- Responsible for ensuring project technical milestones are satisfied
- High Customer Contact
  - Engineering Focal Point
  - Project Execution
- Covers project activities for DP C → DP E

PE

- Single-Domain Engineering Team Leader
  - Either Single or Multi-discipline
- Responsible for WBS Activity
- Responsible for completing committed activities and tasks
- Limited Customer Contact
  - Technical Content
- Covers project at various Project Milestones (as needed)

Engineering Leadership “Work Allocation”



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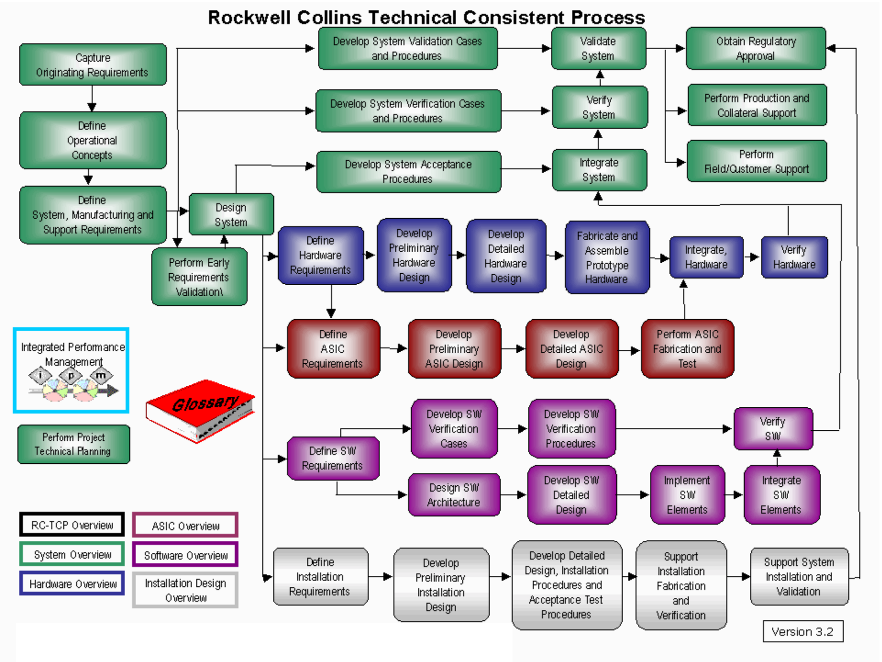
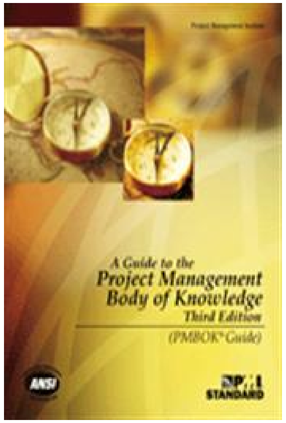
Consistent Process Model: First Steps

- Technical Consistent Process (TCP) v1.0 model released in 2000
  - Provides technical process definition
  - Provides minimal project management definition
    - Some planning activities
    - Perform config control, change control, peer reviews, technical reviews



Project Management 101

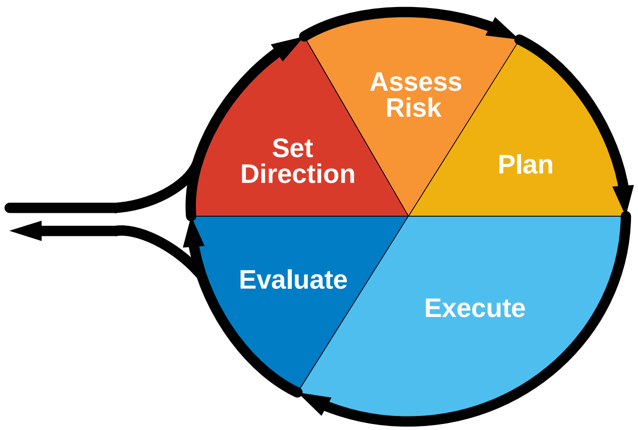
- Acquired Project Management course
  - Fundamentals of Project Management
- Convened project management focus group
- Reviewed Project Management Institute (PMI) Body of Knowledge

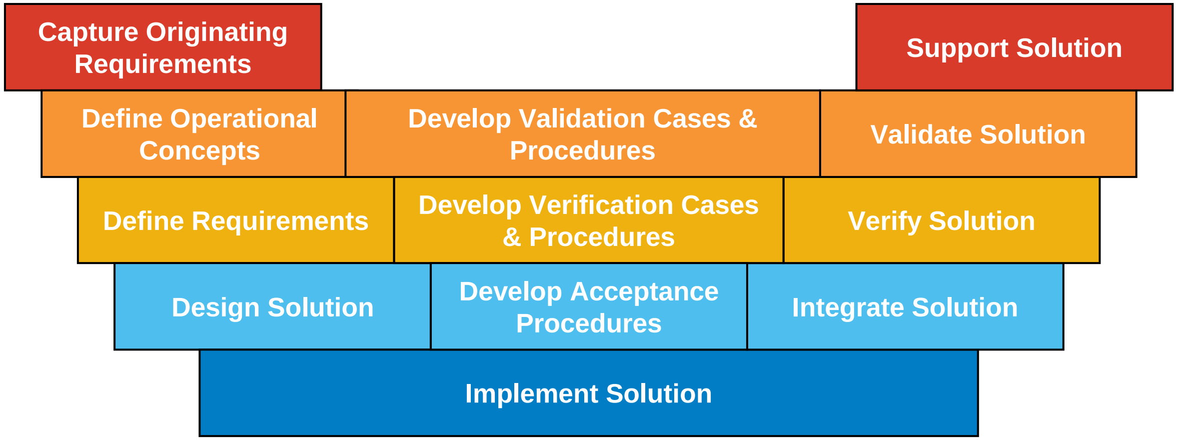


- Revisited SAP Project Management model

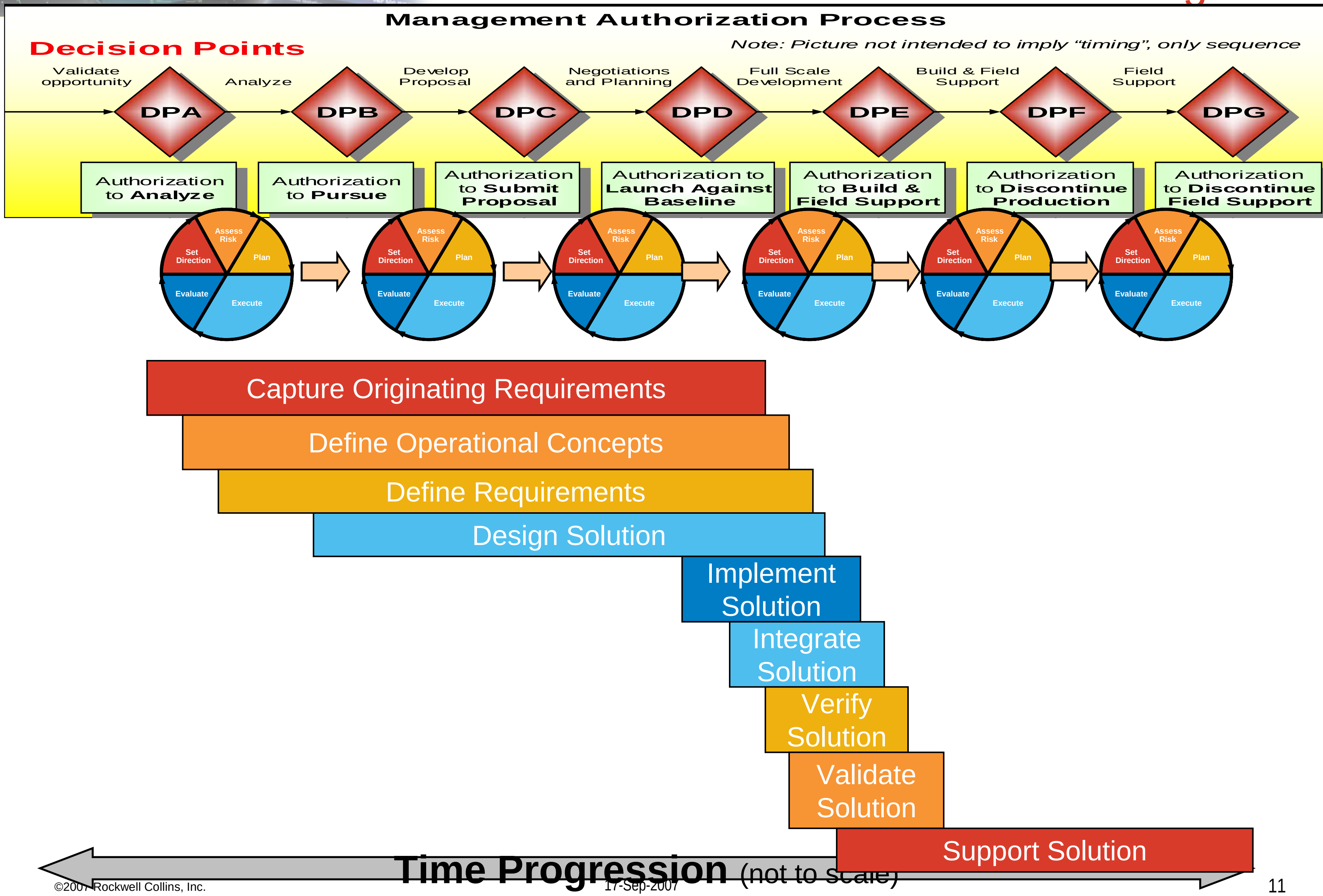
Technical Management Activities (TMA)

Technical Development Activities (TDA)





Process Integration



Project Management vs. Systems Engineering

- System Engineer $\not\in$ Technical Project Manager

Can be same person, but roles are distinct

- Technical Project Manager:
  - Interdisciplinary role - management
  - Provides project management services for design and development activities for a given project
  - Cost, schedule, and project performance accountability to LCVSM
  - Work governed by TMA process; oversees overall TCP execution
- System Engineer
  - Interdisciplinary role – technical
  - Provides technical definition for a specific domain area for a project (technical domain expert)
  - Technical performance accountability to PE & TPM
  - Work governed by TDA process; technical coordination between disciplines

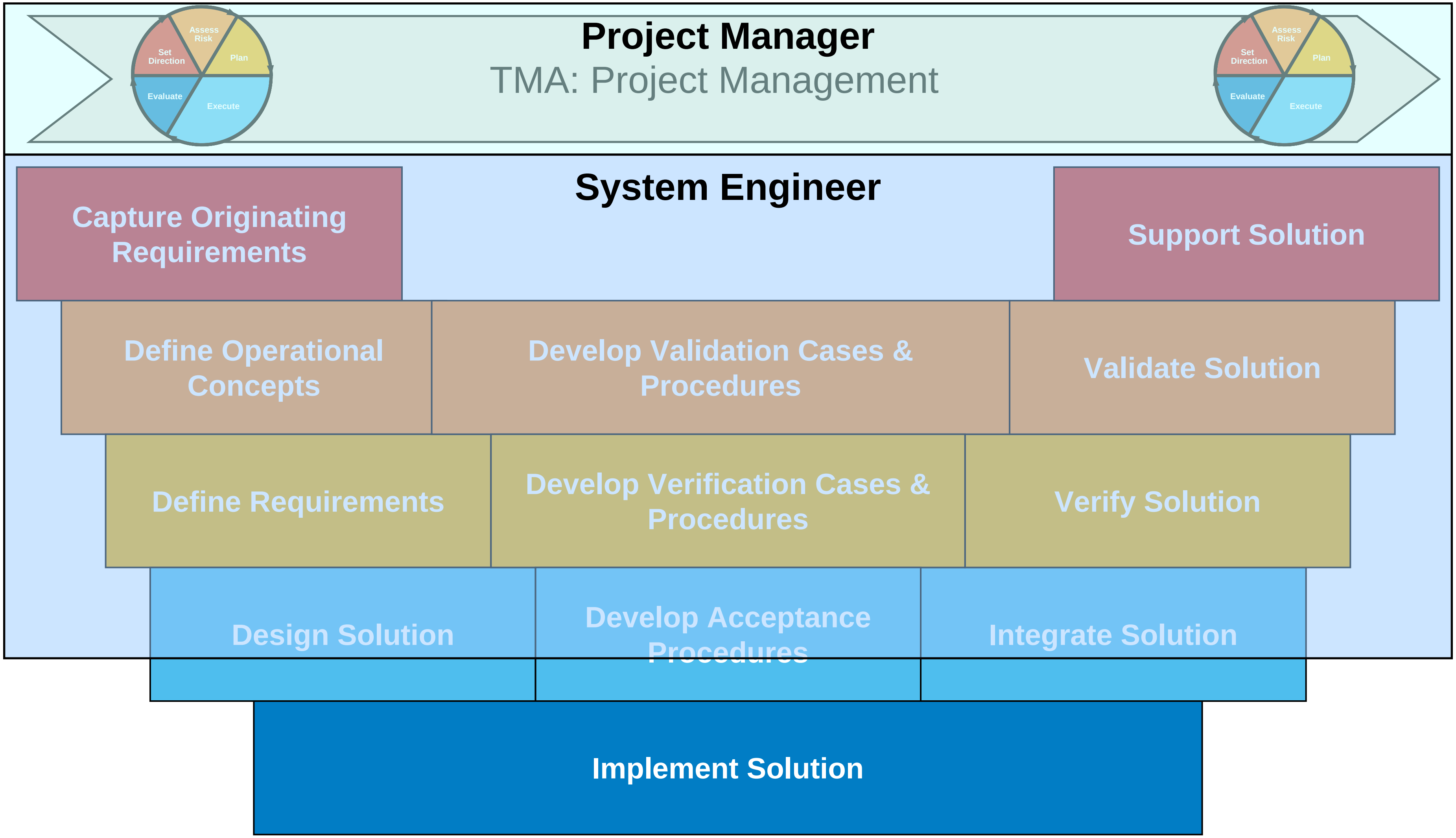
Project Management vs. Systems Engineering

- System Engineer $\notin$ Project Engineer

Can be same person, but roles are distinct

  - Project Engineer:
    - Can be from any discipline (system, software, hardware, etc)
    - Provides project management services for a specific domain and/or discipline area for a given project
    - Cost, schedule, and project performance accountability to TPM
    - Work governed by TMA process; oversees TCP execution
  - System Engineer
    - Typically specifically trained as a system engineer
    - Provides technical definition for a specific domain area for a project (technical domain expert)
    - Technical performance accountability to PE & TPM
    - Work governed by TDA process; technical coordination between disciplines

Project Management vs. Systems Engineering



Conclusion

- Understand context of RCI engineering process evolution
  - Needed to address shortcomings in project management specific processes
- Understand roles & responsibilities of project managers within RCI culture
  - LCVSM, TPM, and PE: Varying levels of project management responsibility
- Explore the relationship of project management to product development processes
  - Complimentary TMA and TDA process models: project management and product development
- Explore the roles of systems engineering vs. project management
  - Complimentary roles – shared by some, distinct in others

Environment, Safety, and Occupational Health (ESOH) – Design Considerations to Support Sustainability and Readiness

Ms. Patricia Huheey
Office of the Deputy Under Secretary of Defense
Installations and Environment
October 23, 2007

Outline

- Background
  - Vision, Mission, Goals, and Organization
  - Role in Acquisition
  - Installation Readiness Issues and Initiatives
- Acquisition ESOH Policy and Guidance
  - Policy Objectives and Goals
  - Life Cycle ESOH Risks
  - DoD Policy and USD(AT&L) Memorandums
  - Programmatic ESOH Evaluation (PESHE)
- Acquisition ESOH Focus Areas and Initiatives
  - Program Oversight and Reviews
  - Updates to Policy and Guidance
  - Defense Acquisition University (DAU) Curricula
  - System Safety - ESOH Management Evaluation Criteria for DoD Acquisition
  - “ESOH in Acquisition - Integrating ESOH into Systems Engineering” Booklet

ODUSD(I&E) Vision and Mission

Vision: Installations assets and services are available when and where needed, with the joint capabilities and capacities necessary to effectively and efficiently support DoD Missions.

Mission: Provide installations assets and services necessary to support our military forces in a cost effective, safe, sustainable and environmentally sound manner.

ODUSD (Installations and Environment)

Acquisition, Technology and Logistics

DUSD (Installations & Environment)
Mr. Philip W. Grone

Integrated Management Support
Mr. Donald Leonard

Office of Economic Adjustment
Mr. Patrick O'Brien

ADUSD (Installations)
Mr. Chuck Williams

Base Realignment & Closure
Mr. Peter Potochney

Business Enterprise Integration
Ms. Lora Muchmore

Housing & Competitive Sourcing
Mr. Joseph Sikes

Installations Requirements & Management
Dr. Get Moy

ADUSD (Environment Safety & Occupational Health)
Mr. Alex Beehler

Environmental Management
Mr. Shah Choudhury, Acting

Environmental Readiness & Safety
Mr. Curtis Bowling

Armed Forces Pest Management Board
Col Richard Johnson

Defense Explosives Safety Board
Mr. Thierry Chiapello

Emerging Contaminants
Ms. Shannon Cunniff

ODUSD(I&E) Role in Acquisition

- AT&L Advisor for ESOH considerations
- Oversight of ACAT ID, IAM, and AT&L Special Interest programs
- Develop/Contribute ESOH Input to DoDI 5000.2
- Identify OSD ESOH expectations in the Defense Acquisition Guidebook (DAG)
- Provide additional guidance for policy implementation on the Acquisition Community Connection (ACC)
- Provide ESOH input to CJCSI/M 3170.01 - JCIDS

ADUSD(ESOH) Supports Acquisition

- Chair DoD Acquisition ESOH IPT
  - Component consensus on ESOH in Acquisition policy and guidance
  - Influence NSS Acquisition Policy and JCIDS
  - Opportunity to share tools, best practices, and collaboration across OSD and Components
- Member of the Defense Acquisition Policy Working Group (DAPWG)
  - DoDI 5000.2 and Defense Acquisition Guidebook
  - ESOH Special Interest Area on the ACC site
- Member of Defense Safety Oversight Council (DSOC)
  - Co-chair DSOC Integration Group
  - Acquisition and Technology Programs Task Force

Training and Testing Are Important As Ever

- Realistic training requires realistic training environments
- Ability to field and use advanced military technology is fundamental to U.S. warfare
- Our weapons and tactics require increasingly large battlespaces
- Readiness is perishable – Skills must be maintained through regular training
- OPTEMPO, PERSTEMPO are up - ready access to training is essential
- Live Fire is fundamental to training

We must train as we fight because we fight as we train

Bases and Ranges Are at Risk

<u>Encroachment</u>: Restrictions that inhibit accomplishment of our live training and testing as required

- Force Readiness is fundamentally linked to the quality and frequency of test and training
- The impact of encroachment Is broad -- affecting our ability to execute realistic air, ground, and naval training across the nation, as well as beyond its borders

Incompatible Development….

…Inhibits Effective Military Training

- Increases complaints of noise, dust and other training related activities from new neighbors
- Reduces or eliminates any future mission flexibility
- Limits off-range species and habitat conservation opportunities

Fort Bragg, NC

Sustainable Ranges Initiative

- Sustainable Ranges are the Foundation for Future Training
  - Readiness Depends on Range Access and Live Fire Capability
  - Sound Range Stewardship Supports Training Realism and Environmental Excellence
  - Working "Outside the Fence" is a Must
- Requires a Comprehensive Solution That Integrates
  - Training Requirements
  - Natural Environment & Stewardship
  - Community Economic and Social Interests
  - Legislative and Regulatory Framework

Range Sustainment Initiative Strategy Elements

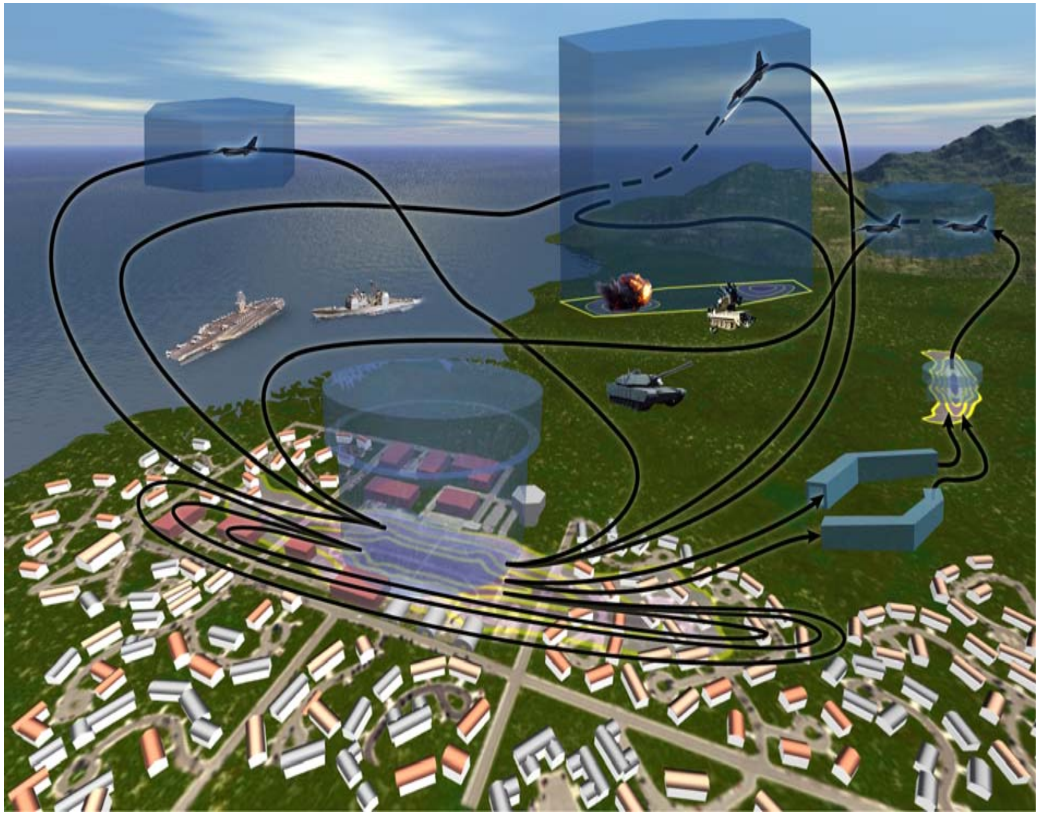
- **Policy**
- **Programming**
- **Leadership & Organization**
- **Legislation & Regulation**
- **Outreach and Engagement**
- **Compatible Land Use & Buffering**
- **Comprehensive Reporting**

Natural Infrastructure Management (NIM)

- To be mission ready at the installation and range level, in addition to built infrastructure and personnel, DoD needs an adequate supply of air, land, and water assets (i.e., natural infrastructure) to train, test, and perform its varied missions
- The Natural Infrastructure Capability Work Group (NICWG) is working to develop and implement a common framework for NIM to support mission requirements

NIM Framework

- NICWG tested and refined two major aspects of a common management framework:
  - Natural Infrastructure assessments provide data to determine NI "readiness" to meet current and emerging operational requirements
  - Natural Infrastructure asset valuation is used to assess military, ecological, and economic values provided by NI assets



Acquisition programs and operators must provide system specific data to support NIM

Acquisition ESOH Policy and Guidance

Plan Ahead & Influence Design

- Identify system life cycle ESOH risks early to influence design, not address them afterwards as operational considerations
- System design is most effectively influenced through the system engineering (SE) process
  - Active participation in the IPTs is critical to success
- ESOH hazards and associated risks are best managed using a standard approach and structured process
- E, S, and OH inputs to SE must be optimized across the disciplines to meet cost and performance requirements and needs throughout the life cycle

Life Cycle ESOH Risks

- ESOH risks may include
  - Toxic and hazardous materials and wastes
  - Environmental and occupational noise
  - Impacts to personnel safety and occupational health
  - Inability to maintain regulatory compliance requirements
- Need to manage ESOH risks associated with
  - Routine system development, testing, training, operation, sustainment, maintenance, and demilitarization/disposal
  - System failures or mishaps, including critical software failures
  - Life cycle cost, schedule, and performance impacts from ESOH compliance requirements

Top Level DoD Acquisition ESOH Policy

- Use a total systems approach to minimize or eliminate characteristics that produce environmental, safety or occupational health hazards, where practicable and cost effective
- Address safety throughout the acquisition process
- Use the system safety methodology in MIL-STD-882D to eliminate ESOH hazards where possible and manage ESOH risks where hazards cannot be eliminated
- Ensure formal risk acceptance at designated management level
- Document hazardous materials associated with the system and plan for their safe disposal, beginning during system design
- Provide safety releases to developmental and operational testers prior to any test using personnel

Recent USD(AT&L) Policy Memorandums

- Defense Acquisition System Safety, 23 September 2004
  - Use Standard Practice for System Safety, MIL-STD-882D to manage ESOH risk
  - Report ESOH risk status and acceptance decisions at technical and program reviews
- Reducing Preventable Accidents, 21 November 2006
  - Develop process to provide ESOH input for JCIDS
  - Address the status of each High and Serious ESOH risk and compliance with applicable safety technology requirements at all program reviews
  - PMs will support system-related Class A and B mishap investigations
- Defense Acquisition System Safety – ESOH Risk Acceptance, 7 March 2007
  - Formal acceptance of ESOH risks prior to exposing people, equipment, or the environment to a known system-related ESOH hazard
  - User representative formal concurrence for Serious and High ESOH risks

Programmatic ESOH Evaluation (PESHE)

- PESHE document communicates ESOH planning and the status of ESOH risk management for the system
- PESHE must include:
  - Identification of ESOH responsibilities
  - The strategy for integrating ESOH considerations into the systems engineering process
  - Identification of ESOH risks and their status
  - A description of the method for tracking hazards throughout the life cycle of the system
  - A compliance schedule for National Environmental Policy Act (NEPA) and Executive Order 12114
- All programs, regardless of ACAT, are required to prepare a PESHE to support Program Initiation for Ships, MS B, MS C, and Full-Rate Production Decision Review

Acquisition ESOH Focus Areas and Initiatives

ACAT I Program Oversight/Reviews

- Participate in MS review process
  - Attend program WIPT/OIPT meetings
  - OSD coordination/review of program documents
    - Acquisition Strategy
    - PESHE
  - Assist Component and program staff to
    - Clarify DoDI 5000.2 ESOH policy requirements
    - Emphasize integration of ESOH into SE
    - Focus on life cycle ESOH risk management
- Developing a pilot to identify procedures to implement briefing ESOH risks at acquisition program reviews
  - Defining expectations of PM reporting is critical

Acquisition ESOH Policy and Guidance Updates

- Input to DoDI 5000.2 (in SD 106 coordination)
  – Updated and moved ESOH requirements to the new Enclosure 12 - Systems Engineering
  – Incorporated the 3 USD(AT&L) memorandums
  – Clarified existing DoDI 5000.2 policy requirements
  – Hazardous materials, wastes, and pollutants (discharges/emissions/ noise) associated with the system must be included in the PESHE
  – PM shall provide system-specific analyses and data to support other organizations' NEPA and EO 12114 analyses
- Updated ESOH input for the Defense Acquisition Guidebook
  – "System Safety Analyses" added to the SE V model Inputs and Outputs and to "The Wall Chart"
  – Clarified expectations
- Initiating update for ESOH Special Interest Area on the ACC

System Safety - ESOH Management Evaluation Criteria

- Tool to assess an acquisition program's overall management of ESOH as part of SE process
  - Technical and Program Reviews (self assessment)
  - Milestone Review Process (oversight assessment)
- Four key areas for evaluation
  - Planning
  - Requirements Analysis
  - Hazard Analysis
  - Resources
- Assessment criteria for key each area for each life cycle phase, and can be combined for overall rating for each life cycle phase
- To be incorporated into Defense Acquisition Program Support (DAPS) SE Assessment Methodology
- Available on ACC at https://acc.dau.mil/esoh and included in booklet handouts

DAU Curricula

- Working with DAU to improve ESOH training for the acquisition workforce since 2000
- Review courses and provide ESOH input consistent with current DoD policy, guidance, and best practices
  - Courses reviewed include Acquisition; Systems Engineering; Program Management; Logistics; Test and Evaluation; Software Acquisition; Facilities Engineering; and Production, Quality, and Manufacturing
- Technical Management Functional Advisor support and DSOC funding provided means to more aggressively review and provide ESOH input for the courses over past 2 years

DAU CLE009 - System Safety in SE

- ODUSD(I&E) and ODUSD(A&T)/SSE effort
- Roadmap for using the MIL-STD-882D system safety methodology for eliminating or mitigating ESOH hazards and associated risks
- Discusses system safety/ESOH efforts to be conducted throughout the system's life cycle
- Helps define how ESOH and SE communities should work together
- Available on-line since April 2005 at https://learn.dau.mil
- Over 1600 graduates to date

Integrating ESOH Into SE Booklet

- Builds on CLE009 and depicts when ESOH activities should be performed to influence system design throughout the systems engineering process

- System Safety-ESOH Management Evaluation Criteria are included

Copies available here, and will be discussed during System Safety Track, Session 4B7 on Thursday, 25 Oct 10:15am-12pm

Way Ahead

- Continue to mature the ESOH risk management process for acquisition
  - Update guidance on PESHE requirements and expectations
  - Revise MIL-STD-882D to better support DoD policy and initiatives, expand importance of integration into SE, and inclusion of environmental efforts
  - Provide guidance on implementing ESOH risk acceptance policy
  - Develop tools to help identify system ESOH requirements
- Continue to lead and support ESOH efforts to influence system design and development

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Engineering for System Assurance – Legacy, Life Cycle, Leadership

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Chair, DHS Software Assurance Forum Working Group on Processes and Practices

Past Convener, ISO/IEC JTC1/SC7 WG9, System and Software Assurance

Outline

- System Assurance Defined
- The System Assurance Problem Space
- Software As A Root Cause Problem
- Engineering Shortfalls
- Seven Systems Engineering Community Leadership Challenges
- Guidance For Systems Assurance
- Standardization In Support Of Systems Assurance
- Summary

System Assurance Defined

System assurance is the level of confidence that the system functions as intended and is free of exploitable vulnerabilities, either intentionally or unintentionally designed or inserted as part of the system.

System Assurance Problem Space

- Large-scale systems and systems of systems represent a complex supply chain integrating
  - Proprietary and open-source software
  - Legacy systems
  - Hardware
  - Firmware
- These systems are sourced from multiple suppliers who employ people from around the world
- Most systems we encounter today contain software elements and most depend upon software for a good portion of their functionality
- Technologies to build reliable and secure software are inadequate
  - Our ability to develop software has not kept pace with hardware advances
  - Can’t construct complex software-intensive systems for which we can anticipate performance
- **Assurance is a full life cycle systems-level problem**

Software As A Root Cause Problem

- System risk has dramatically increased due to the simultaneous growth in software vulnerabilities and in threat opportunities
- Risk management processes inadequately address these threats and risks
- Threats presented by suppliers of software products and services are not adequately identified and analyzed
- Development and acquisition processes inadequately address software security
- There is a fundamental lack of both the scientific understanding of software risks and the capabilities to effectively diagnose and mitigate in the in a timely manner

Source: J. Jarzombek. DOD Software Assurance Initiative: Mitigating Risks Attributable to Software. DOD Software Assurance Forum, July 2004.

Or, More Succinctly . . .

- There is a failure to assure correct, predictable, safe, secure execution of complex software in distributed environments
- Inadequate attention is given to the total lifecycle issues, including impacts on lifecycle cost and risk associated with the use of commercial or reused products and components

Source: G. Draper (ed.), Top Software Engineering Issues Within Department of Defense and Defense Industry. National Defense Industrial Association, Arlington, VA, August 2006.

System Assurance Engineering Shortfalls

- Current techniques for specifying, building, demonstrating, and verifying assured components with well understood properties are not cost-effective or scaleable
- Cannot easily infer the assurance properties of a system, or systems of systems, from component level assurance information
- Don't know enough about composability problems and emergent behavior when components are interconnected in large-scale systems and systems of systems
- Exhaustive testing to rule out vulnerabilities is generally not feasible due to the size and complexity of our systems of interest

Source: G. Draper (ed.), Top Software Engineering Issues Within Department of Defense and Defense Industry. National Defense Industrial Association, Arlington, VA, August 2006.

The Systems Engineering Challenge

Integrating a heterogeneous set of globally engineered and supplied proprietary, open-source, and other software; hardware; and firmware; as well as legacy systems; to create well-engineered integrated, interoperable, and extendable systems whose security, safety, and other risks are acceptable – or at least tolerable.

Systems Engineering Community Leadership Challenges #1 – Acquisition

Collaboration to develop new approaches and improve existing approaches, standards, and tools that address systems assurance issues throughout the acquisition life cycle and the supply chain

Source: G. Draper (ed.), Top Software Engineering Issues Within Department of Defense and Defense Industry. National Defense Industrial Association, Arlington, VA, August 2006.

Systems Engineering Community Leadership Challenges #2 – Engineering Practices

Integration of systems and software engineering practices for producing system architectures and resulting systems that are resistant to intrusion and compromise

Source: G. Draper (ed.), Top Software Engineering Issues Within Department of Defense and Defense Industry. National Defense Industrial Association, Arlington, VA, August 2006.

Systems Engineering Community Leadership Challenges #3 – Research

Sponsor research into new modalities for system composition to meet specific assurance objectives

Source: G. Draper (ed.), Top Software Engineering Issues Within Department of Defense and Defense Industry. National Defense Industrial Association, Arlington, VA, August 2006.

Systems Engineering Community Leadership Challenges #4 – Quality Attributes

Define systems and software assurance quality attributes that can be addressed during architectural tradeoffs

Source: G. Draper (ed.), Top Software Engineering Issues Within Department of Defense and Defense Industry. National Defense Industrial Association, Arlington, VA, August 2006.

Systems Engineering Community Leadership Challenges #5 – Standardization

Encourage the development of commercial standards addressing vulnerability management throughout the supply chain, including product-level and component-level specifications and standards for detecting component vulnerabilities

Source: G. Draper (ed.), Top Software Engineering Issues Within Department of Defense and Defense Industry. National Defense Industrial Association, Arlington, VA, August 2006.

Systems Engineering Community Leadership Challenges #6 – Policy and Guidance

Develop policy, guidance, and training for the acquisition of systems with desired assurance properties

Source: G. Draper (ed.), Top Software Engineering Issues Within Department of Defense and Defense Industry. National Defense Industrial Association, Arlington, VA, August 2006.

Systems Engineering Community Leadership Challenges #7 – Life Cycle Planning

Ensure that life cycle issues and tradeoffs associated with the incorporation of commercial components and reused software into systems are clearly addressed in program plans, systems engineering plans, test and evaluations plans, and during periodic reviews

Source: G. Draper (ed.), Top Software Engineering Issues Within Department of Defense and Defense Industry. National Defense Industrial Association, Arlington, VA, August 2006.

Guidance For Systems Assurance - 1

- ***Systems Assurance – Delivering Mission Success in the Face of Developing Threats***
  – An NDIA guidebook intended to supplement the knowledge of systems (and software) engineers who have responsibility for systems for which there are assurance concerns

NDIA/DoD System Assurance Guidebook – Scope

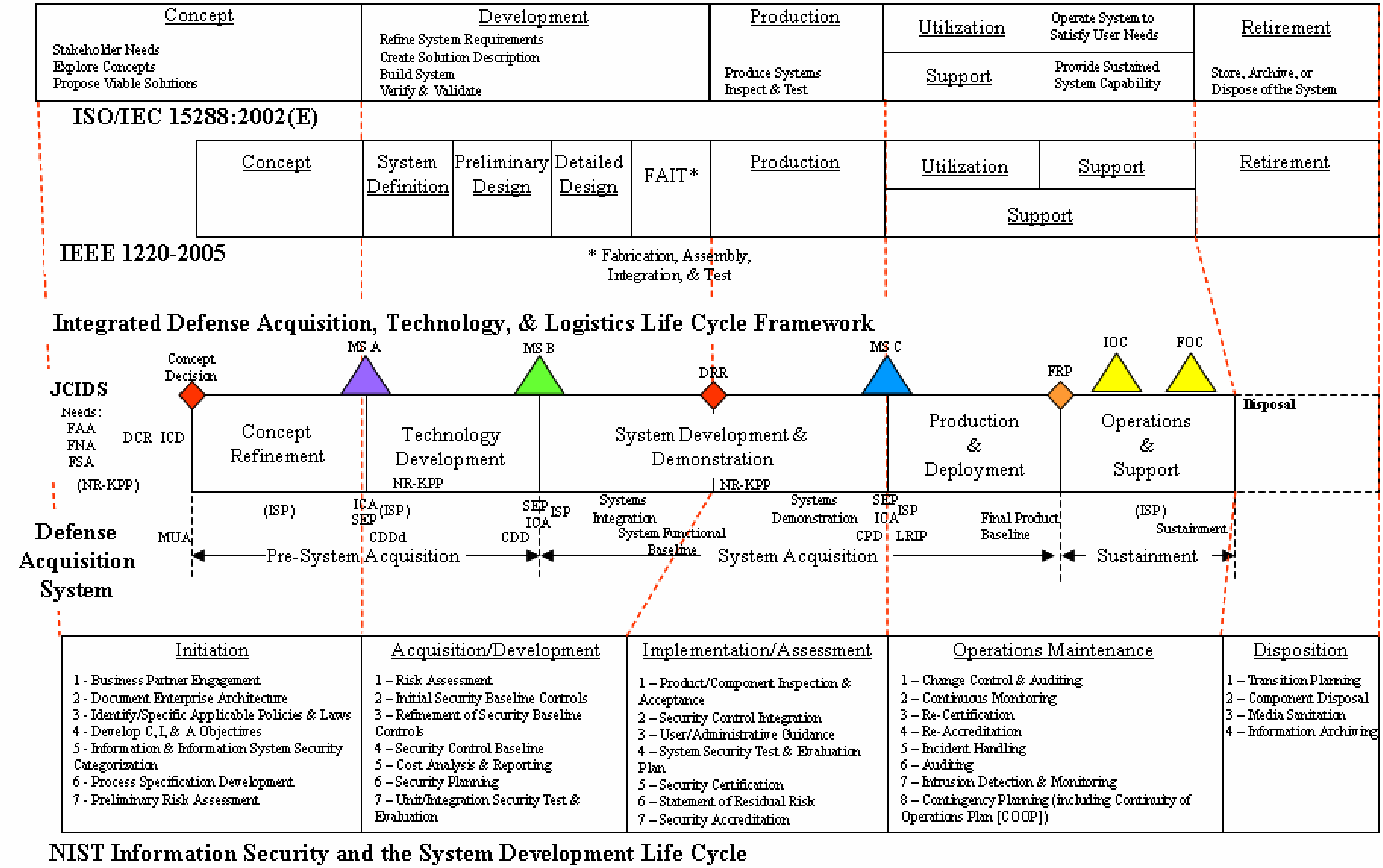
- Practical guidance for the Government acquisition community, industry, academia, and other commercial and government partners
- Synthesis of knowledge gained from existing practice, recommendations, policy, and mandate, rather than reinventing the wheel
- Recap of important concepts and principles from foundational documents, standards, and mandates, and discussion of them in the larger context of systems assurance as presented by the White Paper

NDIA/DoD System Assurance Guidebook – Mapped To ISO/IEC/IEEE 15288

- Agreement Processes
  - Acquisition
  - Supply
- Project Processes
  - Project Planning
  - Project Assessment
  - Project Control
  - Decision-making
  - Risk Management
  - Configuration Management
  - Information Management
- **Assurance Case Process**
- Technical Processes
  - Stakeholder Requirements Definition
  - Requirements Analysis
  - Architectural Design
  - Implementation
  - Integration
  - Verification
  - Transition
  - Validation
  - Operation
  - Maintenance
  - Disposal

- Enterprise Processes
  - Enterprise Environment Management
  - Investment Management
  - System Life Cycle Process Management
  - Resource Management [including human resource training]
  - Quality Management

Alignment of Standards In The Guidebook



Guidance For Systems Assurance - 2

- ***State of the Art Report on Software Security Assurance***
  - An IATAC/DACS report identifying and describing the current state of the art in software security assurance, including trends in:
    - Techniques for the production of secure software
    - Technologies that exist or are emerging to address the software security challenge
    - Current activities and organizations in government, industry, and academia, in the U.S. and abroad, that are devoted to systematic improvement of software security
    - Research trends worldwide that might improve the state of the art for software security

Guidance For Systems Assurance - 3

- ***Secure Software Assurance: A Guide to the Common Body of Knowledge to Produce, Acquire, and Sustain Secure Software***
  - A DHS guidebook intended as a framework to identify workforce needs for competencies and leverage standards and best practices to guide software-related curriculum development

Guidance For Systems Assurance - 4

- ***Security in the Software Life Cycle: Making Software Development Processes – and the Software Produced by Them – More Secure***
  - An DHS report providing a compendium of methodologies, life cycle process models, sound practices, and supporting technologies that would, if adhered to, increase software security

Guidance For Systems Assurance - 5

- ***Software Assurance in Acquisition: Mitigating Risks to the Enterprise***
  - A DHS report intended to provide guidance on enhancing supply chain management through improved risk mitigation and contracting for secure software

Standardization In Support Of Systems Assurance - Languages

- ISO/IEC SC22 (Languages)
  - ISO/IEC Technical Report – Guidance for Avoiding Vulnerabilities through Language Selection and Use
    - Comparative guidance spanning multiple programming languages
    - Goal: Avoidance of programming errors that lead to vulnerabilities

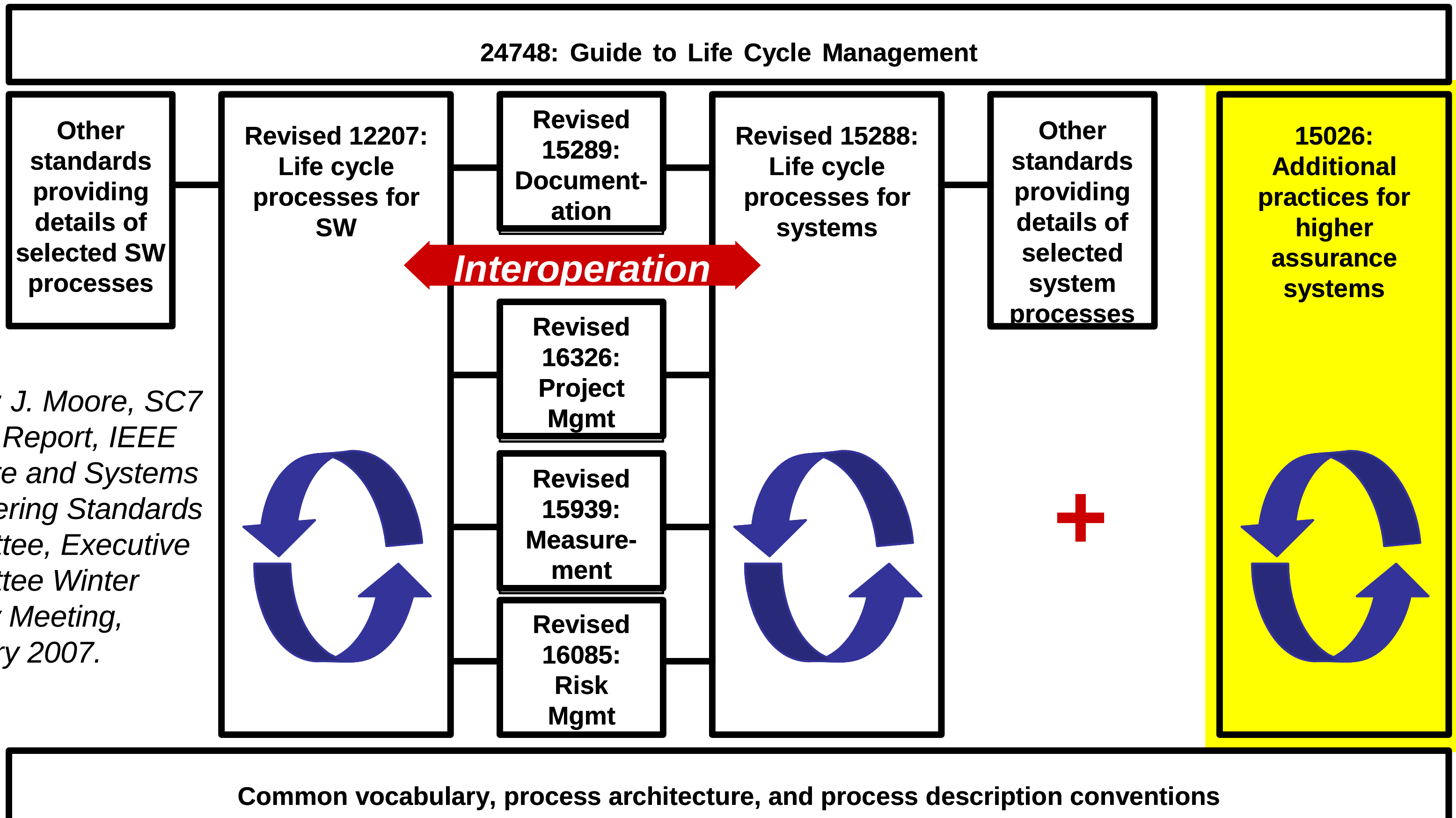
Standardization In Support Of Systems Assurance - Security

- ISO/IEC SC27 (IT Security Techniques)
  - ISO/IEC 21827, System Security Engineering Capability Maturity Model (SSE CMM)
  - ISO/IEC 15443 (FRITSA), A framework for IT security assurance
  - ISO/IEC DTR 19791, Assessment of Operational Systems

Standardization In Support Of Systems Assurance - Safety

- IEC SC 65A (Functional Safety)
  - – IEC 61508, Functional Safety
    - Risk-based approach for determining the required performance of safety-related systems
    - Requirements based on common underlying principles to facilitate:
      - – Supply chain efficiencies
      - – Clear communication of requirements
      - – Development of techniques and measures
      - – Development of conformity assessment models

Standardization In Support Of Systems Assurance – System and Software Assurance



Source: J. Moore, SC7 Liaison Report, IEEE Software and Systems Engineering Standards Committee, Executive Committee Winter Plenary Meeting, February 2007.

ISO/IEC/IEEE 15026, System and Software Assurance

- A 65-page draft has been balloted
  - It incorporates material from FCD 12207, FCD 15288, ISO/IEC 15289, IEEE Std 1228 and the safety and security extensions to CMMI
- The draft contains requirements and guidance for:
  - Assurance cases
  - Associated documents, e.g. assurance plan, reports, analyses
- The process view is comprehensive—it touches every process of 15288 and 12207 (except for the enterprise processes)
- Joint comment resolution is in progress

Source: J. Moore, Proposed Revision of ISO/IEC 15026: Status Report, IEEE Software and Systems Engineering Standards Committee, Executive Committee Summer Plenary Meeting, July 2007.

Current Draft of Scope Clause

- This International Standard provides requirements for the life cycle including development, operation, maintenance, and disposal of systems and software products that are critically required to exhibit and be shown to possess properties related to safety, security, dependability, or other characteristics
- It defines an ***assurance case*** as the central artefact for planning, monitoring, achieving and showing the achievement and sustainment of the properties and for related support of other decision making
- ***The interaction of the requirements for the assurance case with life cycle processes implies a normative interpretation of the processes from ISO/IEC 15288 and ISO/IEC 12207***
- Finally, the standard provides requirements, in addition to those of ISO/IEC 15289, for information artefacts that result from those processes

Source: J. Moore, Proposed Revision of ISO/IEC 15026: Status Report, IEEE Software and Systems Engineering Standards Committee, Executive Committee Summer Plenary Meeting, July 2007.

Relationships to Other Standards

- The provisions regarding process in this international standard make extensive normative references to **ISO/IEC 12207:2007 and ISO/IEC 15288:2007**, the international standards for software and system life cycle processes.
- Users of this international standard will probably require risk management and measurement processes that are more fully detailed than the treatment provided in ISO/IEC 15288. Two international standards, **ISO/IEC 16085** and **ISO/IEC 15939** are useful in this regard.
- The provisions regarding the assurance plan and assurance case are intended to be compatible with the provisions of ISO/IEC 15289:2006 for information items resulting from life cycle processes.
- Some material regarding assurance planning and its supporting analyses has been adapted from **IEEE Std 1228:1994**.
- The provisions regarding product characteristics are intended to be generally consistent with those of the **ISO/IEC 25000** series of standards related to product quality, the **ISO/IEC 27000** series of standards related to information security management systems, the **IEC 61508** standard on functional safety, and various standards of IEC TC 56 related to dependability.
- **ISO/IEC TR 15443**, Information technology--Security techniques--A framework for IT security assurance, discusses the need for arguments and evidence in the IT context.

Current Draft Conformance Clause

- This international standard is **intended to be used in conjunction with ISO/IEC 12207 and ISO/IEC 15288**. This standard provides requirements and guidance in addition to that of the referenced standards. To conform to this international standard, one conforms to the referenced standards and conforms to the additional requirements of this international standard.
- It is permitted to assert conformance for **specified properties of the system or to specified portions of the system** if the assertion is accompanied by a **clear statement of the limitations** ...
- ***One may assert conformance to this standard for specific product claims related to stated critical properties or characteristics for specifically identified versions of products or portions of products under specified conditions***. ... Assertions of conformance that relate only to the lack of limited categories of faults or weaknesses must not be stated as claims for more general properties such as security or safety. ...

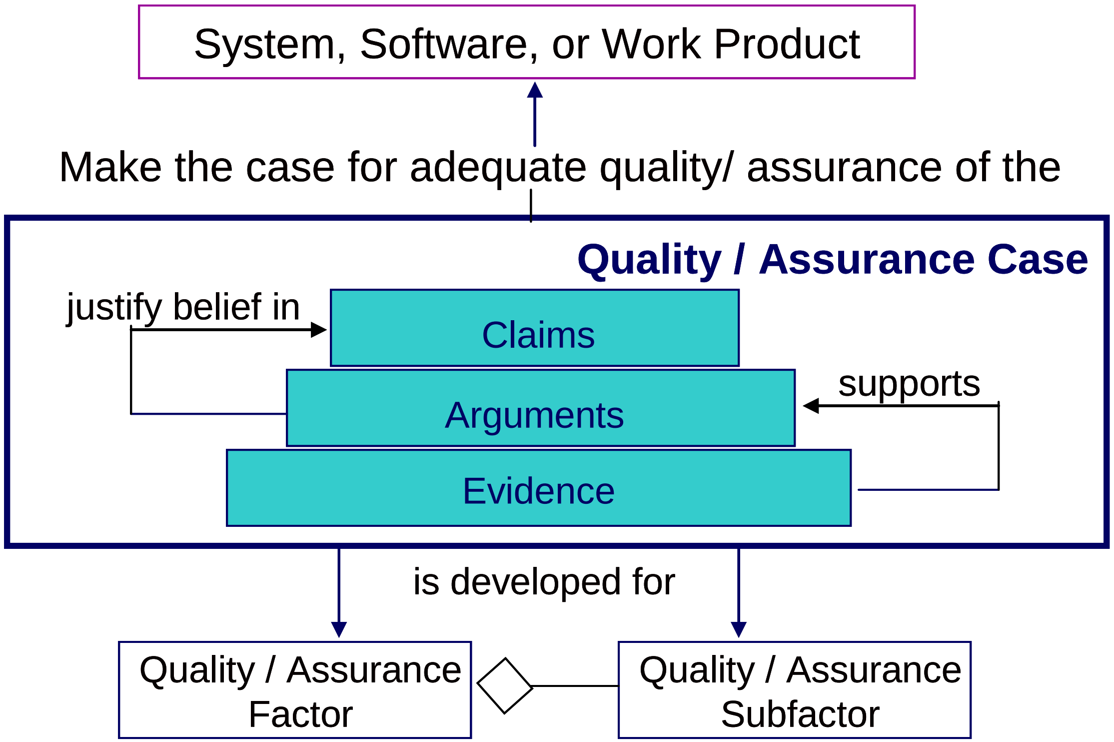
Source: J. Moore, Proposed Revision of ISO/IEC 15026: Status Report, IEEE Software and Systems Engineering Standards Committee, Executive Committee Summer Plenary Meeting, July 2007.

General Requirements on Assurance Cases

- **The project shall establish and maintain an assurance case**.
- **The project shall ensure that**:
  - Goals and objectives for safety, security, dependability and any other designated critical properties are formulated.
  - Product assurance-related objectives, properties, or characteristics are explicitly selected for special attention and application of this standard to address the goals and objectives.
  - Requirements for the achievement of these objectives, properties, or characteristics are defined.
  - Measures for the requirements are selected and related to the desired characteristics.
  - Criteria for the achievement or degree or achievement of these objectives, properties, or characteristics are selected and traced to requirements.
  - Approaches for achieving the objectives, properties, or characteristics are planned, designed, and implemented, as well as demonstrating and documenting that achievement.
  - The extent of achievement is continuously monitored, documented, and communicated to stakeholders and managers.
  - An assurance case documenting and communicating the extent of achievement is specified, developed, and maintained as an element of the system.
  - The artefacts for documenting, analyzing, and communicating the required or claimed properties and characteristics and the extent of achievement are specified, developed, and maintained.
  - Requirements of the approval authority are satisfied and necessary licenses or certifications are received.

Source: J. Moore, Proposed Revision of ISO/IEC 15026: Status Report, IEEE Software and Systems Engineering Standards Committee, Executive Committee Summer Plenary Meeting, July 2007.

The Assurance Case In Relation To The Product And Its Quality/Assurance Factors



Attributes

- Clear
- Consistent
- Complete
- Comprehensible
- Defensible
- Bounded
- Addresses all life cycle stages

Adapted from a slide by Joe Jarzombek who, in turn, credited IEEE CS alternative proposal for 15026 and CMU SEI QUASAR tutorial by Donald Firesmith, March 2007

Summary

- The systems engineering challenge for systems assurance is in integrating a heterogeneous set of globally engineered and supplied proprietary, open-source, and other software; hardware; and firmware; as well as legacy systems; to create well-engineered integrated, interoperable, and extendable systems whose security, safety, and other risks are acceptable – or at least tolerable.
- Joint industry and Government efforts are ongoing to understand the strengths and weaknesses of current engineering practices and to provide appropriate guidance
- National and international standards efforts are also capturing and codifying minimum acceptable practice regarding engineering for systems assurance
- Systems engineers must lead the way in sensitizing their stakeholders to the assurance implications of engineering decisions made throughout the life cycle and instill practices in their own engineering organizations that facilitate system assurance

References

G. Draper (ed.), *Top Software Engineering Issues Within Department of Defense and Defense Industry*. National Defense Industrial Association, Arlington, VA, August 2006.

K. Goertzel (ed.), *State of the Art Report on Software Security Assurance, Draft*. DOD Information Assurance Technical Assistance Center (IATAC) and the DOD Data and Analysis Center for Software (DACS), March 2007.

K. Goertzel (ed.), *Security in the Software Life Cycle: Making Software Development Processes – and the Software Produced by Them – More Secure, Draft 1.1*. U.S. Department of Homeland Security, July 2006.

J. Jarzombek. *DOD Software Assurance Initiative: Mitigating Risks Attributable to Software*. DOD Software Assurance Forum, July 2004.

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C. Powell and D. Kleiner (eds.), *Systems Assurance – Delivering Mission Success in the Face of Developing Threats*. National Defense Industrial Association, Arlington, VA, January 2007.

S. Redwine (ed.), Secure *Software Assurance: A Guide to the Common Body of Knowledge to Produce, Acquire, and Sustain Secure Software*, *Draft 1.1*. U.S. Department of Homeland Security, September 25 2006.

Software Assurance in Acquisition: Mitigating Risks to the Enterprise, Draft 1.0. U.S. Department of Homeland Security, March 2007.

For More Information . . .

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M&S Education for the Acquisition/T&E Workforce Requirements Analysis

23 Oct 2007

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Overview

- Project Overview
- Observations on the requirements and the current state of the body of knowledge

Market Segmentation

Educating the Acquisition and T&E Workforce in the More Effective Use of M&S:

Market Schema

<u>Career Levels</u>
Advanced/Senior
Intermediate/Journeyman
Basic/Entry

<u>Acquisition Career Fields</u>
Program Management
Systems Engineering
Test and Evaluation
Contracting
Logistics
Facilities Engineering
Auditing
Science & Technology
Information Technology
Business, cost estimating, and financial mgmt
Industrial and/or contract property management
Manufacturing, production and quality assurance
Purchasing

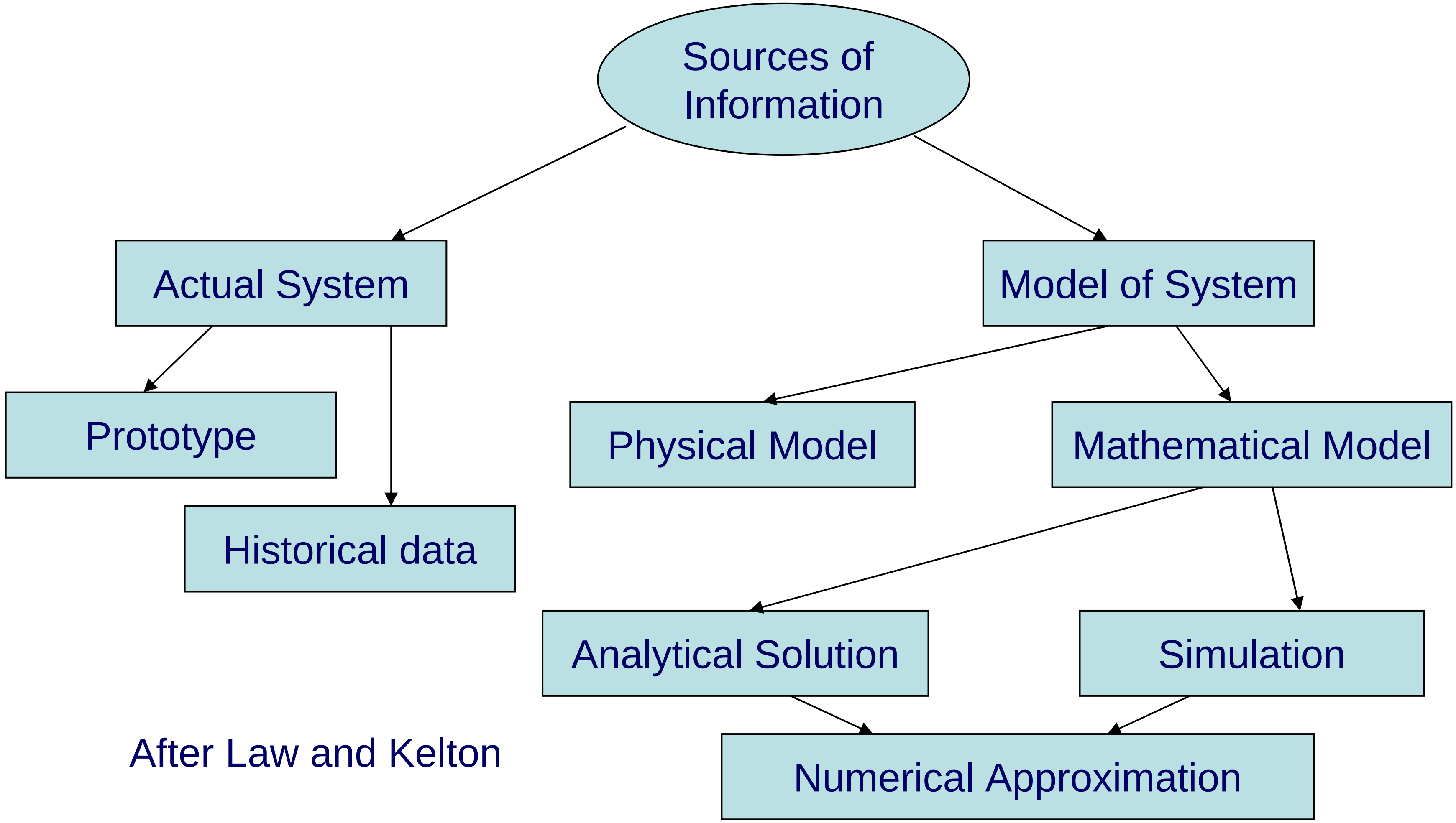
Acquisition/T&E Subset

Training
Planning
M&S Workforce
Acquisition/T&E Workforce
Analysis
Experimentation

Where we are today

- Work Completed
  - DoD M&S Human Capital Strategy - COCOM visits conducted, Survey responses being collected
  - Consolidated BOK - Drafted, feedback received from all but 1 community
  - Learning Matrix – Draft Complete
    - Educational catalog delivered
    - ESRs developed
    - Initial gap analysis complete
    - Academic partners identified and participating (GMU, JHU/APL, ODU, UAH, UCF, and UCSD)
- Near Term Activities – Through December 2007
  - Complete Spiral One
    - Incorporate Stakeholder feedback to Learning Matrix (10 October)
    - Shaping Meeting (10 October)
    - BoK/HCS completion (expected completion 1 Dec)
  - Spiral Two: Learning Architecture/Instructional Framework Development
    - Develop module/syllabi framework based on learning matrix
- FY08 Funding will enable development of education and evaluation program

Overall Approach: Information Trade Space



After Law and Kelton

High Level ESR Development

- Process:
  - Initial list of ESR's developed by stakeholders and NPS inter-disciplinary team.
  - Stakeholders involved in iterative process to expand and refine ESR's to current list.
- Results:
  - 17 Process ESR's –Focused on the process of choosing when to use which models and simulations.
  - 9 Acquisition ESR's –Focused on applying M&S in the acquisition lifecycle.
  - 5 Test and Evaluation ESR's –Focused on the role and use of M&S in test and evaluation.
  - 5 Operational ESR's –Focused on the use of operational and logistic M&S to support Acquisition/T&E activities.
  - 14 Engineering ESR's –Focused on the use of engineering models to support Acquisition/T&E activities.

Note: High Level ESR's listed in backup slides.

Workforce Mapping

- Mapping of ESRs to workforce needs (Learning Matrix)
- Performed by Academic Partners, including GMU, JHU/APL, ODU, UAH, UCF, and UCSD
- Three pieces provided to complete mapping:
  - Workforce segmentation definitions
    - Career Fields - Project Managers, Systems Engineers, and T&E workforce
    - Career Levels - Basic/entry, intermediate/journeyman, and advanced/senior career levels
    - Follows DoD 5000.52M descriptions
  - Competence Levels
    - Four competence levels defined and mapped to Bloom's taxonomy – General Awareness, Understand, Application, and Mastery
  - Detailed ESR's – High level ESR's decomposed into "mappable" level of granularity

Note: Career field/level descriptions and competence level descriptions provided in backup slides.

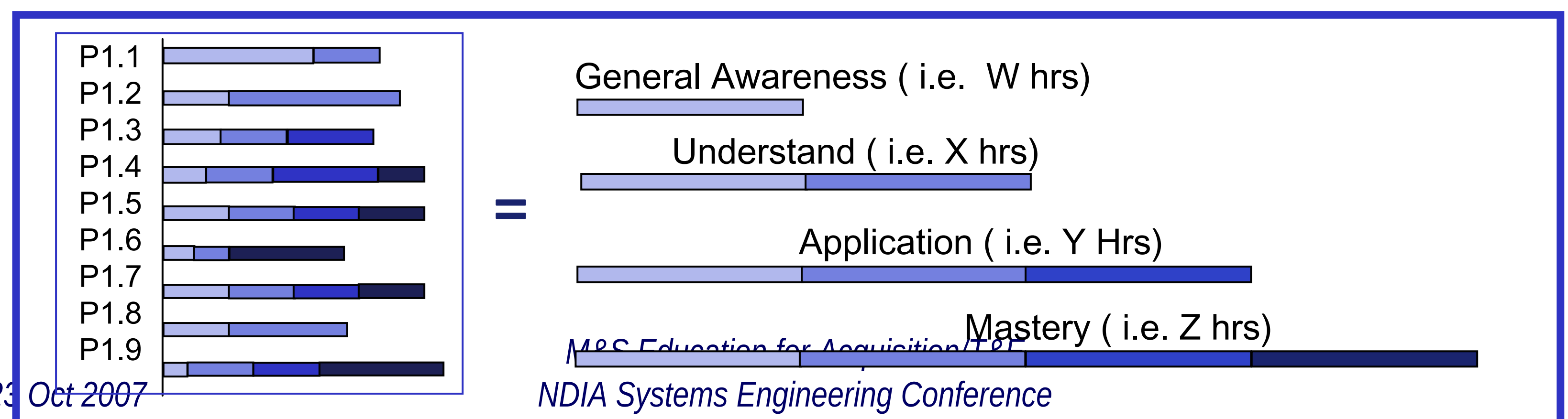
Workforce Mapping Example
Learning Matrix for one ESR (of 50)

	P13: Understand the trades between using a general model and a custom model, including the VV&A implications.								
	P13.1	P13.2	P13.3	P13.4	P13.5	P13.6	P13.7	P13.8	P13.9
PM									
Basic	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness
Intermediate	Understand	Application	Application	Application	Application	Application	Application	Mastery	Mastery
Advanced	Understand	Understand	Understand	Understand	Understand	Understand	Understand	Understand	Understand
SE									
Basic	Understand	Understand	Understand	Understand	Understand	Understand	Understand	Understand	Understand
Intermediate	Understand	Application	Application	Applica					
Advanced	Understand	Application	Application	Applica					
T&E									
Basic	Understand	Understand	Understand	Unders					
Intermediate	Understand	Application	Application	Applica					
Advanced	Understand	Application	Application	Applica					

P13.1 Define general model and custom model
P13.2 State advantages of general model
P13.3 State disadvantages of general model
P13.4 State advantages of custom model
P13.5 State disadvantages of custom model
P13.6 State VVA requirements of general model
P13.7 State VVA requirements of custom model
P13.8 Describe situations where each type of model is more appropriate
P13.9 Given historical examples of each, describe and analyze which is more appropriate

Current work (complete Dec 07)

- Goal – Develop Course/Module “Syllabi”
  - Syllabi outline desired content of educational elements that will satisfy the needs identified in the Learning Matrix.
  - Syllabi combined into a consolidated and cohesive Learning Architecture.
- Each module developed to highest level of competency required for the subject matter (not always mastery)
- Modules constructed so that slices of the content can be extracted for lower required competency levels



Next phase

- Courses built to target audience
  - Desired length of courses and competency levels required determine subset of modules combined into course structure
  - Human Capital Strategy survey feedback will help guide requirements.
- Courses tested

Academic Partners

- Air Force Institute of Technology
- Defense Acquisition University
- * George Mason University
- * Johns Hopkins University/ Applied Physics Lab
- * Old Dominion University
- Stevens Institute
- Texas A&M
- * University of Alabama, Huntsville
- * University of California, San Diego
- * University of Central Florida

Process

P1) Understand the critical decisions in the acquisition lifecycle, the analysis plans to support them, and the information required.

P2) Understand the role of modeling and simulation prior to the concept decision to identify and quantify capability gaps and to estimate how well new program concepts might address those gaps.

P3) Understand the costs, benefits, and risks of using physical testing, modeling and simulation, and historical data to provide information for acquisition decisions.

P4) Know the technical aspects of the domain of application.

P5) Know the taxonomy and hierarchies of models and simulations and be able to select appropriately for a given situation. Understand the types of architectures and role of architectures in tying together and communicating requirements, analysis, modeling and simulation, design, and development planning to all stakeholders. Understand how M&S is deployed in different environments (Live, Virtual, and Constructive). Understand the differences between standalone and confederated M&S applications and when to apply each in various situations. Be familiar with the simulation interoperability standards.

Process

P6) Establish and write valid modeling and simulation requirements using a process that includes modeling and simulation needs analysis, generation of valid modeling and simulation requirements, functional decomposition and conceptual model development, and issuance of "built to" or "buy to" performance specifications. Understand how models and simulations evolve in fidelity, resolution, and scope as the program life cycle progresses.

P7) Estimate the cost, develop a schedule, and measure the performance of a modeling and simulation plan. Identify the areas of risk and develop a mitigation strategy.

P8) Know how to incorporate modeling and simulation, through a Simulation Support Plan, into a systems engineering plan and a test and evaluation master plan.

P9) Know and require the best practices and standards in modeling and simulation as developed in key case studies.

P10) Know the models and simulations used in a given domain, their inputs and outputs, and their strengths and weaknesses.

Process

P11) Know the common terminology and high level roles and responsibilities, as well as the underlying philosophy, principles, and methodologies used in VV&A efforts, especially those applied in DoD.

P12) Be able to correctly match the level of detail of a model with that of the information needed to support a decision, and understand the connection between the decision to be made and the estimation of measures from the model.

P13) Understand the trades between using a general model and a custom model, including the VV&A implications.

P14) Design a sound simulation study for a given set of objectives.

P15) Apply appropriate statistical techniques to the analysis of simulation output.

P16) Know how to manage and reuse existing models, data, and simulations appropriately and assure that new products developed are designed and prepared for reuse.

P17) Manage the data strategy for an M&S effort including estimating the resources necessary to obtain sufficient data to populate the model.

Acquisition

A1) Understand the types, role and value of formal Modeling and Simulations, and their various characterizations for application to systems management, particularly with regard to design, testing, training, production, cost estimation, manning, and logistical simulations.

A2) Understand the concepts of Simulation-Based Acquisition (SBA) across the entire program life cycle, in order to reduce the time, resources, and risks associated with the acquisition process.

A3) Be able to discern among M&S proposals, relative to measurable program contributions, and decide on the appropriate program office level of expenditure on M&S tools throughout the program life cycle. Distinguish whether custom or off-the-shelf products will be best suited for the program's purpose.

A4) Understand the role of M&S in the contract proposal process, how M&S efforts will be defined and specified, and the value of M&S deliverables under an acquisition contract. Determine their need for continuous improvement, vis-à-vis M&S cost/benefit trades throughout the program life cycle.

Acquisition

A5) Know where to find organizational M&S resources to identify the number and types of models currently in use, best practices from case studies, where they originated, how they might be leveraged in support of an acquisition program.

A6) Be aware of the Modeling and Simulation Resource Repository as a single source for information about and access to DoD models, simulations, data sources, algorithms, and other M&S resources in order to facilitate reuse and avoid duplication.

A7) Understand experimental design, level of model detail, and M&S application as a pre-test prediction tool. Use M&S to make informed engineering tradeoff analyses through the program's Decision Risk Analysis process. Understand the analysis of M&S outputs/measures.

A8) Understand the critical interrelationships and balance between modeling and simulation and more traditional forms of test and evaluation (T&E) – particularly operational and live-fire test and evaluation.

A9) Know how to employ M&S to explore reliability and interoperability issues.

Test and Evaluation

T1) Quantify the risk of using M&S in place of live testing. For open systems, quantify the risk of using M&S to evaluate a single system component in place of testing an entire configuration.

T2) Integrate M&S, live test, prototype data, historical data, component data, and scale model data into a coherent testing decision.

T3) Understand the different types of testing (i.e. unit, integration, interoperability, and operational) and identify the utility, limitations and risks for use of M&S in each.

T4) Understand the potential opportunities for employing M&S in the test planning and execution process.

T5) Be aware of existing M&S T&E facilities used within the DoD.

Operational/Logistics

O1) Understand the role of operational and logistical models in the acquisition life cycle and when they are used.

O2) Know the properties of a representative suite of operational models across the services.

- Required inputs, Outputs, Assumptions, Implementation requirements, Costs, Time required, Adaptability and extensibility, VVA status

O3) Know the properties of a representative suite of logistical models across the services.

- Required inputs, Outputs, Assumptions, Implementation requirements, Costs, Time required, Adaptability and extensibility, VVA status

O4) Understand abstractions and lower levels of realism in operational and logistics models.

O5) Understand and be able to model the components of logistics systems, including Supply Chain, Storage systems, Facilities, Production, Inventory management, Transportation & distribution, Replenishment policies

Engineering/Technology

E1) Structural Mechanics, Shock and Vibrations - Understand basic structural mechanics including stress-strain relations, buckling and fatigue, shock and vibration, and finite element methods in M&S.

E2) Fluid Dynamics and Weapon System - Understand the basics of computational fluid dynamics for CFD application and use for M&S. Fluid dynamics of subsonic and supersonic weapons, warheads and their effects.

E3) Dynamics and Control - Understand the basics of M&S in process and multi-physics (mechanical, electrical & hydraulic) based dynamic system controls.

E4) Thermodynamics and Heat Transfer - Understand the fundamentals of thermodynamics and heat transfer with applications to M&S in engineering power cycles, propulsion and auxiliary system cycle analysis and design.

E5) Materials and Fabrication - Possess a basic understanding of the materials technology associated with manufacturing, welding and corrosion control. Have an introduction to composite, superconducting materials, and fiber optics as applied to M&S.

Engineering/Technology

E6) Acoustic and Electromagnetic Systems - Have a general awareness of the fundamentals of acoustic and electromagnetic wave propagation and application to DoD systems.

E7) Military Platform Systems Engineering - Appreciate the broad-based design oriented M&S approach for complex platforms that interact with air-land-sea-based hardware systems, command and control systems and combat systems.

E8) Computers - Recognize basic computer system architecture, operating systems, networking and introduction to engineering software and their applications. Have an introduction to structured programming languages such as Fortran and C, and the use of such tools for code development. Gain exposure to finite element/difference codes, with application to solve engineering problems including experience with selected software packages.

E9) Electrical Engineering - Understand basic circuit analysis including DC and AC circuits. Gain an exposure to the construction and operating characteristics of rotating machinery, static converters, power distribution systems and multi-phased circuits.

Engineering/Technology

E10) C4ISR - Value the requirement for C4ISR in systems. Understand the basic components, methods and alternatives for transferring information from one point to another both internal and external to the system being considered. Have the ability to analyze all available technologies for achieving rapid/effective/jam-resistant information transfer.

E11) Networks – Understand the principles of networks applied to military applications including physical, command and control, and social networks and their implications for engineering design of systems.

E12) Environment – Understand the fundamentals of terrestrial science (geology, oceanography, meteorology, and near-earth space science) to describe how systems interact with and are influenced by their environment.

E13) Human Systems Integration – Understand the principles of Human Systems Integration. Describe the applications of M&S to support HSI design and analysis.

E14) Aerodynamics – Understand the principles of aerodynamics with applications to M&S. Understand the cost, schedule, and iterative development nature of simulation testbeds used for flight software development through formal qualification.

Conclusions

Backup

Program Management Career Field

(from DoD 5000.52M)

- Positions Held:
  - All of functions of a PMO or PEO
  - Program integrators and analysts, program managers, PEOs, and deputies
  - Support and management positions throughout the workforce
- Responsibilities:
  - Balance the factors that influence cost, schedule, and performance
  - Interpret and tailor application of the DoD 5000 Series regulations
  - Ensure that high-quality, affordable, supportable, and effective defense systems are delivered to the warfighter as quickly as possible

PM Career Levels

- Basic/Entry
  - Member working in PM support role
  - Example jobs include R&D coordinator, test officer staff officer, integrator, analyst, etc.
- Intermediate/Journeyman
  - Managers of PEO/PMO office functions
  - Deputy PM or PM for small programs, PEO staff roles
- Advanced/Senior
  - ACAT 1 or 2 PM, PEO

SPRDE – Systems Engineering Career Field (from DoD 5000.52M)

- Positions Held:
  - Scientists and engineers supporting science and technology and acquisition programs, projects, or activities to accomplish the responsibilities below
- Responsibilities:
  - Planning, organizing, monitoring, managing, overseeing and/or performing research and engineering activities relating to the design, development, fabrication, installation, modification, sustainment, or analysis of systems or systems components

SE Career Levels

- Basic/Entry
  - Design, development, fabrication, installation, modification, sustainment, or analysis of systems or systems components
  - Workforce executing these tasks across a broad range of application domains
- Intermediate/Journeyman
  - Managers of teams working on application level functions
  - Line managers at warfare centers, project leads for R&D projects
- Advanced/Senior
  - CHENG, Warfare center execs, project systems engineers

Test and Evaluation Career Field

(from DoD 5000.52M)

- Positions Held:
  - T&E team members; T&E leads for programs; Service, Agency, and Facility T&E managers, engineers, scientists, operations research analysts, system analysts, computer scientists; other technical personnel who plan, perform, and manage T&E tasks in support of acquisition
- Responsibilities:
  - Plan, monitor, manage, and conduct T&E of prototype, new, fielded, or modified C4ISR and weapon or automated information systems, equipment or material
  - Analyze, assess, and evaluate test data and results and prepare assessments of system performance and reports of T&E findings

T&E Career Levels

- Basic/Entry
  - Test planning, execution, and analysis functions performed for DT and OT, including interoperability and other certification testing requirements
  - Includes testing in Live, Virtual and Constructive environments
  - Workforce executing these tasks across a broad range of application domains
- Intermediate/Journeyman
  - Managers of testing activities
  - T&E agency team leads, Project T&E managers
- Advanced/Senior
  - Testing activity executives, PMs, Milestone decision authorities

Competence Levels

Competence Level	Bloom’s Taxonomy	Definition	Examples and Keywords
General Awareness	Knowledge	Recall or recognize data or information.	**Examples:** Recite a policy. Quote prices from memory to a customer. Knows the safety rules. **Keywords:** defines, describes, identifies, knows, labels, lists, matches, names, outlines, recalls, recognizes, reproduces, selects, states.
Understand	Comprehension	Understand the meaning, translation, interpolation, and interpretation of instructions and problems. State a problem in one's own words.	**Examples:** Rewrites the principles of test writing. Explain in one's own words the steps for performing a complex task. Translates an equation into a computer spreadsheet. **Keywords:** comprehends, converts, defends, distinguishes, estimates, explains, extends, generalizes, gives Examples, infers, interprets, paraphrases, predicts, rewrites, summarizes, translates.
Application	Application	Use a concept in a new situation or unprompted use of an abstraction. Applies what was learned in the classroom into novel situations in the work place. Put theory into practice, use knowledge in response to real circumstances	**Examples:** Use a manual to calculate an employee's vacation time. Apply laws of statistics to evaluate the reliability of a written test. **Keywords:** applies, changes, computes, constructs, demonstrates, discovers, manipulates, modifies, operates, predicts, prepares, produces, relates, shows, solves, uses.

References:
http://www.nwlink.com/~donclark/hrd/bloom.html
http://faculty.washington.edu/krumme/guides/bloom1.html
http://www.businessballs.com/bloomstaxonomyoflearningdomains.htm

Competence Levels

Competence Level	Bloom's Taxonomy	Definition	Examples and Keywords
Mastery	Analysis	Separates material or concepts into component parts so that its organizational structure may be understood. Distinguishes between facts and inferences.	**Examples:** Troubleshoot a piece of equipment by using logical deduction. Recognize logical fallacies in reasoning. Gathers information from a department and selects the required tasks for training. **Keywords:** analyzes, breaks down, compares, contrasts, diagrams, deconstructs, differentiates, discriminates, distinguishes, identifies, illustrates, infers, outlines, relates, selects, separates.
	Synthesis	Builds/develops new structures, systems, models, approaches, or patterns from diverse elements. Put parts together to form a whole, with emphasis on creating a new meaning or structure.	**Examples:** Write a company operations or process manual. Design a machine to perform a specific task. Integrates training from several sources to solve a problem. Revises and process to improve the outcome. **Keywords:** categorizes, combines, compiles, composes, creates, devises, designs, explains, generates, modifies, organizes, plans, rearranges, reconstructs, relates, reorganizes, revises, rewrites, summarizes, tells, writes.
	Evaluation	Make judgments about the value of ideas or materials. Assess effectiveness of whole concepts in relation to values, outputs, efficacy, viability; critical thinking, strategic comparison and review.	**Examples:** Select the most effective solution. Hire the most qualified candidate. Explain and justify a new budget. **Keywords:** appraises, compares, concludes, contrasts, criticizes, critiques, defends, describes, discriminates, evaluates, explains, interprets, justifies, relates, summarizes, supports.

References:
http://www.nwlink.com/~donclark/hrd/bloom.html
http://faculty.washington.edu/krumme/guides/bloom1.html
http://www.businessballs.com/bloomstaxonomyoflearningdomains.htm

DoD Software Engineering and System Assurance

Focusing on Top Software Issues

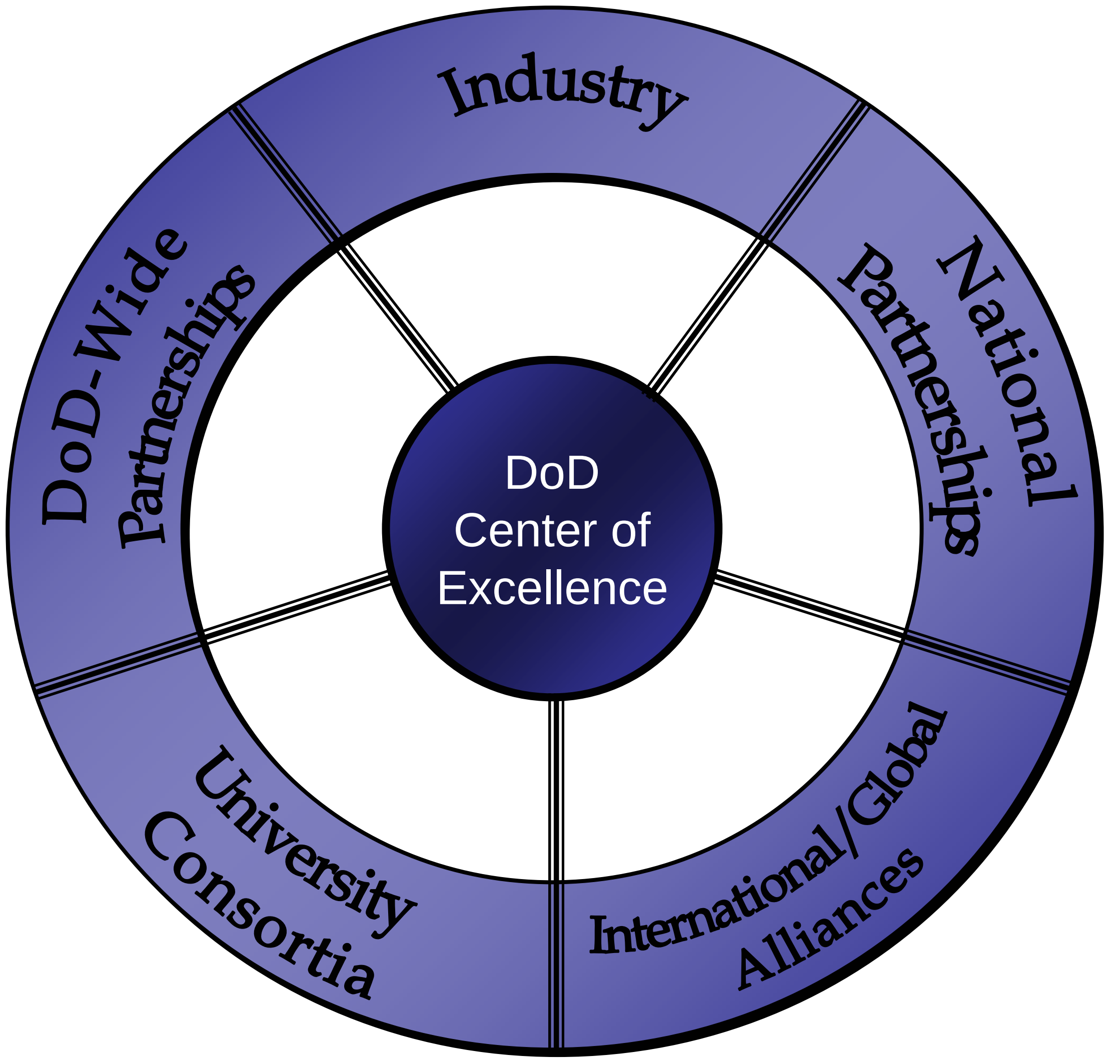
Kristen Baldwin

Deputy Director, Software Engineering and System Assurance

Office of the Under Secretary of Defense

Acquisition, Technology and Logistics

Establishing a DoD Engineering Center of Excellence



OSD Software Engineering and System Assurance

- Support Acquisition Success
- Improve State-of-the-Practice of Engineering
- Leadership, Outreach and Advocacy
- Foster Resources to Meet DoD Needs

Recap of Activities Since Last NDIA Conference

- Documented software issues, needs
  - Software Industrial Base Study completed
  - NDIA Top Software Issues Workshop Report
  - Defense Software Strategy Summit Report
- Created partnerships
  - Established network of DoD software POCs
  - Chartered the NDIA Software Committee and Expert Panel
  - Bi-weekly software collaboration exchanges with Government, Academia, and Industry
  - Restructured the US-UK-AUS Trilateral Working Group
- Performed gap analysis
  - Identified ongoing software initiatives; mapped them to issue areas
  - Two outcomes:
    1. Identified initiatives that deserve cross-DoD attention
    2. Identified gaps where attention is needed

Common Goal: Provide visibility to key initiatives; Focus attention on gaps

SW Issue/GAP Workshop Findings

March 2007

Primary Software Focus Groups*

**based on NDIA Top SW Issues, OSD Program Support Reviews, and DoD Software Summit findings*

Software Acquisition Management
- Standards – O, N
- DAG Ch 4/7 – O, AF
- Prog Spt – O, All
- Contract Language – A, M, N
- SW Estimation – GAP
- Lifecycle Policy – AF
- Risk Identification - GAP

Software Development Techniques
- Agile – O, SEI
- Architecture – A, SEI
- COTS – SEI
- Open Source – AF
- Sustainment – GAP
- SW Interoperability – GAP
- SW Test - GAP

SW & SE Integration
- Requirements – GAP
- SE/SW Process Int – O
- SW Council – N
- SW Dev Plan – N
- SW in SEP – N
- SW in Tech Reviews – N
- SW Quality Attributes - GAP

Knowledge Sharing
- Standards – O, N
- DAG Ch 4/7 – O, AF
- Prog Spt – O, All
- Contract Language – A, M, N
- Estimation – GAP
- Lifecycle Policy – AF
- Risk Identification - GAP

Data and Metrics
- SW Metrics – A, O
- SW Cost – O
- SW EVM – DCMA
- SW Estimation - GAP

Human Capital
- Education Sources – N, A
- Leadership Training – A, SEI
- SETA Quals – GAP
- SW Human Cap Strategy – GAP
- Industrial Base – O
- University Curriculum – O
- Workforce Survey - AF

Ongoing
Initiative Owners
- O – OSD/SSA
- A – Army
- N – Navy
- AF – Air Force
- M – MDA
- SEI
- DCMA
- GAP – No activity

Ongoing SW Initiatives (w/owners) and Gaps binned to Focus Groups

Identified Software Gap Areas

- Estimation
- Risk Identification
- Sustainment
- Interoperability
- Test
- Requirements
- Quality Attributes
- Qualifications for Software Support (SETA)
- Human Capital Strategy

Needed step:
Develop plans to define, and begin to address, these gaps

Software In Acquisition Workshop October 16-17, 2007

- Purpose: Off-year workshop (Summit held every 2yrs)
  - Share progress on initiatives against known issues
  - Collaborate on gaps
- Format:
  - Leadership updates
  - Presentations from the community to share progress, experiences
  - Workshops to develop action plans for resolution of key issues
    - Requirements, Risk/Cost Estimation, SW Quality Attributes
- Audience:
  - DoD programs, practitioners, industry, FFRDC, academia
- Community forum focused on software in acquisition

Software Requirements Workshop

Requirements Issues

- Many problems are the same as those we have been trying to fix for 30 years
- We know what to do however we do not incentivize it, pay for it and train for it (e.g. application of IEEE requirements attributes)
- Lack of early and continuous involvement of all relevant SMEs
- We are making changes to software whose existing behavior we do not understand
- Do not have adequate tools, methods and processes for requirements definition
- How are articulated specifications adequate to development derived from capabilities? – especially in a continuous evolution environment
- Requirements are added, changed or deleted without sufficient engineering
- Component cannot operate alone – no one owns the external relationships

Requirements Workshop Recommendations

1. Define an effective "software portfolio" management framework
   – Protect the continuity of systems/software and requirement engineering throughout the software life cycle
2. Implement the techniques we know will work and identify any shortcomings
   – Training
   – Incentives
   – Re-examine IEEE tenets for good requirements
3. Find ways to leverage the malleability of software
   – We need new methods to deal with "on the fly" and/or external requirements: Software has the ability to adapt faster than other elements
   – Build and integrate effective modeling of existing systems and addition of new requirements
   – Identify resources and methods to facilitate planning for extended use
   – Find ways to manage the malleability to minimize risk

Requirements Workshop Recommendations

4. Change our view/perspective of “sustainment” to “continuous evolution”
   – Codify the processes for “reverse engineering” candidates to extract for reuse – system components from government or industry
   – Look at organizational as well as methods and skills to perform continuous evolution
5. Establish a research program
   – Identify the characteristics of requirements engineering in type III systems and how it is distinguished from type I
   – Start to identify good practices

Software Risk/Cost Estimation Workshop

Panel #2: Software Estimation / Risk – Top Level Summary

- **Panel Theme / Focus:**
  - Policy, guidance, and training for improving software acquisition and program execution through synergistic integration of risk management and estimation approaches
- **2006 DoD Software Summit Findings:**
  - Must understand that software is a primary performance, schedule, and cost driver
  - Pressure to rapidly procure new capabilities can inhibit balance of life cycle cost, schedule, and performance expectations to achieve executable programs
  - Software risks and life cycle costs are not consistently accommodated in planning
  - Realistic schedule and effort or cost estimates are often rejected or constrained
  - Reuse, open source, and government off-the-shelf software estimating methods are inadequate

Software Estimation/Risk Recommendations (1 of 2)

- Investigate principles for organizing WBS-related artifacts that address Software Engineering sufficiently
  - Concept definition 6 mo, Proposed Language 12 mo, Revised WBS for Mil-Hdbk-881 and related documents

- Investigate strategies and approaches for developing and evolving an integrated software data repository and related tools to address a broad set of stakeholders (government, industry, academia)
  - Concept definition and definition of measures 6 mo, data collection from sample programs 12 mo, Concept of Operations/Business Plan for wide-scale rollout 18 mo.

- Conduct Root Cause analysis studies to understand the problems in software estimation and the use of estimates in the acquisition process
  - Data gathering of lessons learned and studies 6 mo, Draft analysis 12 mo, Prioritization of high leverage areas for improvement 18 mo

Software Risk/Estimation Recommendations (2 of 2)

- Develop and implement an incremental acquisition approach (as well as the overall acquisition framework) that accommodates the uncertainty associated with early software estimates and allows for adjustment and refinement over time
  - Data gathering 6 mo., analysis of data 12 mo., proposed changes to DoD policy and guidance documents 18 mo.

- Establish policy, related guidance, and recommended implementation approaches for software data collection and analysis across all DoD acquisition programs
  - Concept definition 6 mo, initial analysis of data 12 mo, proposed changes to DoD policy and guidance documents 18 mo

Software Quality Attributes Workshop

Software Quality Attribute Priority Recommendations (1 of 2)

1. **Product: Recommended guidance on engineering issues such as: quantitatively identifying, predicting, evaluating, verifying, and validating Quality Attributes**

Actions to include:

1.1. Address tie-in to KPPs and TPMs

1.2. Identify methods for quantitative assessment of individual and integrated Quality Attributes

1.3. Define the specific pieces of evidence required to pass acquisition milestones

1.4. Identify methods for predicting quality attribute outcomes for the delivered system, throughout the life cycle

2. **Product: Recommendations for improving OSD/Service-level acquisition policy regarding Quality Attributes**

Actions to include:

2.1. Identify benefits of addressing software quality attributes as part of an acquisition risk reduction strategy

2.2. Address gaps in SEP, TEMP, JCIDS, DAG

2.3. Develop model RFP language

2.4. Define expectations for Quality Attribute review during Acquisition Milestone Reviews (e.g. PDR)

Software Quality Attribute Priority Recommendations (2 of 2)

3. Product: Taxonomy of software quality attributes and how they are related

Actions to include:

3.1. Collect and organize definitions of Quality Attributes

3.2. Enumerate relationships to systems quality expectations

3.3. Survey existing information on selection and prioritization of software quality attributes for different classes of programs

4. Product: Program Manager guidance on Introduction to Software Architectural Evaluation of Quality Attributes

Actions to include:

4.1. Evaluate existing guidance documents

4.2. Synthesize results into recommended guidance

5. Product: Collaboration site for collecting data, sharing work products, facilitating on-going discussion

Actions to include:

5.1. Identify host/collaboration tool

5.2. Define site framework/rules

2nd Tier Work Products

1. Product: Catalog of architectural approaches with respect to their Quality Attribute profiles

<u>Actions to include:</u>

1.1. Develop catalog format and approach

2. Product: Process for selecting the subset of Quality Attributes for specific systems of interest

<u>Actions to include:</u>

2.1. Develop strategy for attribute trade-offs

2.2. Identify risk implications

2.3. Develop a checklist of questions to identify attributes important to the stakeholder(s)

3. Product: Recommendations for basic research on quality attributes

<u>Actions to include:</u>

3.1. Address inadequacies in state of the art/state of the practice

4. Product: Guidance on how to engineer quality attributes into systems

<u>Actions to include:</u>

4.1. Define engineering processes to achieve specific quality attribute levels

4.2. Report on current research and practice

3rd Tier Work Products (1 of 2)

1. Product: Guidance on addressing Quality Attributes in the Systems of Systems Context

Actions to include:

1.1. Perform mission thread analysis

1.1.1. Use workshop outline (funded)

1.2. Define systems of Systems software architecture evaluation approach

2. Product: Examination of Root Cause Analysis Workshop data with respect to Quality Attributes implications

Actions to include:

2.1. Examine root cause analysis workshop data to determine quality attribute implication

3. Product: Examination of what DAU teaches regarding Quality Attributes and recommendations for improvement (tied to policy and guidance in #2)

Actions to include:

3.1. Review course material used for PMs and Systems Engineers about quality attributes

3.1.1. Provide recommendations for additions to course materials

4. Product: White paper on how to reason about Quality Attributes in architecture model standards (e.g. DODAF)

Actions to include:

4.1. Produce white paper on how to reason about Quality Attributes in architecture model standards (e.g. DODAF)

3rd Tier Work Products (2 of 2)

5. Product: Guidance on addressing quality attributes of COTS/NDI

Actions to include:

5.1. Develop guidance on addressing quality attributes of COTS/NDI

6. Product: White paper on quality attributes implications of agile methods for large scale defense systems

Actions to include:

6.1. Develop White paper on quality attributes implications of agile methods for large scale defense systems

7. Product: Guidance/lessons learned from commercial practice

Actions to include:

7.1. Collect and provide guidance/lessons learned from commercial practice

OUSD(AT&L)/SSA
FOCUSED INITIATIVES

System Assurance Guidebook Project Description

Issue: Systems are vulnerable to malicious tampering

- Project Description:
  - Provide *practical guidance* on augmenting systems engineering practice for system assurance
  - Synthesize existing knowledge from organizations, standards and best practices
  - Recap concepts from standards
- Opportunity for:
  - Practitioners, academe who implement systems engineering, assurance, safety, security, program protection, etc. into processes and programs
- The project addresses
  - Integration of assurance guidance and practices into systems engineering
- Product:
  - Guidebook on Engineering for System Assurance
- Outcome Goal:
  - Intent is to yield assured program / system with demonstrable evidence of assurance

System of Systems
Project Description

Issue: No common definition, or guidance for SoS

- Project Description:
  - Effort led by the Office of the Secretary of Defense
  - Collaborative Approach with DoD, Industry, Academia
- Purpose
  - 6 month effort addressing areas of agreement across the community
  - Focus on technical aspects of SE applicable across SoS management constructs
  - Vehicle to capture and debate current SoS experience
- Audience
  - Program Managers and Lead/Chief Engineers
- The project addresses
  - Considerations for engineering above a system level
- Product:
  - SoS Engineering Guide, v1.0, Fall 2007
- Outcome Goal:
  - Program managers/chief engineers have requisite knowledge to manage SoS

SW Engineering Graduate Curriculum Project Description

Issue: There is no commonly accepted structure or content for graduate software engineering education

- Project Description:
  - Develop a core curriculum and core competencies for software engineering
- Opportunity:
  - Industrial and government workforce customers of SWE graduate education
  - Academics who provide SWE <u>and SE</u> graduate education
  - Professional societies with a vested interest in SWE <u>and SE</u> graduate education
- The project addresses
  - Inconsistencies in software graduate degrees
  - Poor definition of labor categories and software expertise
  - The divide between systems and software engineers in industry, government, and academia
  - The project will integrate SE principles and practices into a SWE curriculum.
- Product:
  - An approved curric that can be adopted by the community (industry, academia, associations)
- Outcome Goal(s):
  - Software engineers have a more consistent training base

DoD Acquisition Workforce Software Education Project Description

Issue: DAWIA Curriculum does not address software acquisition issues

- Project Description:
  - Compare identified software competencies with current curriculum
  - Update DAU software acquisition management courseware and other career field training to meet competency needs
  - Develop continuous learning modules as part of the DAU Core Plus construct
  - Initial focus on PM and SPRDE career fields
- Opportunity for:
  - Software and career field process owners and practitioners
- The project addresses
  - Methodology for determining software competencies
  - Methodology for developing tailored solutions for each career field
- Product:
  - Updated DAWIA software competencies reflecting latest policies and guidance
- Outcome Goal:
  - Acquisition professionals have requisite software knowledge

SE/SW Process Integration Project Description

Issue: SE and SW have not been well integrated on projects

- Project Description:
  - Study SE and SW processes, capture ongoing harmonization efforts
  - Assess current guidance
  - Identify opportunities for better integration
- Opportunity for:
  - SE and SW process owners or practitioners
  - Academe who teach/study SE and SW
- The project addresses
  - Integration of SW with requirements, risk management and other SE technical and management processes
- Product:
  - Report and recommendations for SW policy, guidance, and tools to better integrate with SE and Acquisition
- Outcome Goal:
  - Software is a major factor in engineering design and acquisition management decisions

CMMI-Acquisition Project Description

Issue: Acquirers lack an appraisable model for acquisition PI

- Project Description:
  - Using GM CMMI for Outsourcing; pilot and generate CMMI-ACQ
  - Involve broad set of acquisition stakeholders to ensure wide application
- Opportunity for:
  - Process improvement stakeholders
  - Acquiring organizations
- The project addresses
  - Identification of key acquirer activities and products
  - Amplification of CMMI core practices to capture acquirer considerations
- Product:
  - CMMI model for Acquisition (built on CMMI foundation for consistency with CMMI-DEV)
- Outcome Goal:
  - Acquisition organizations implement best practices, and institute organizational process improvement

Additional areas for collaboration…and attention

- Additional projects we are looking into:
  - Software earned value guidance
  - Software metrics
  - Software knowledge portal

- Some key gaps remaining:
  - Software sustainment
  - Software test

Our Challenge

- Given the shortage of software resources and critical software reliance
  - We cannot afford to be stovepiped
  - We must integrate across cross-functional perspectives to improve our software capability
- We must focus on long standing software issues
  - Leverage ongoing activities to make a difference
  - Invest in collaborative efforts where there are gaps
- Now...
  - Work together to address software issues
  - Join the DoD SIA Collaborators – participate in bi-weekly collaboration telecons
  - Contribute to workshop action items, and/or ongoing initiatives
  - Contact us at ATL-SSA@osd.mil

Become a DoD Center of Excellence

Backup Slides

Elements of a DoD Strategy for Software

- Support Acquisition Success
  - Ensure effective and efficient software solutions across the acquisition spectrum of systems, SoS and capability portfolios
- Improve the State-of-the-Practice of Software Engineering
  - Advocate and lead software initiatives to improve the state-of-the-practices through transition of tools, techniques, etc.
- Leadership, Outreach and Advocacy
  - Implement at Department and National levels, a strategic plan for meeting Defense software requirements
- Foster Software Resources to meet DoD needs
  - Enable the US and global capability to meet Department software needs, in an assured and responsive manner

Promote World-Class Leadership for Defense Software Engineering

Next Steps

Near Term:

- Determine metrics for each of the 6 Focus Areas
  - Based upon source reports (ie. SW Summit, Top Issues, PSRs, Historical SW Studies)
- Coordinate ongoing initiatives (via Working Group Participation, Defense Software in Acquisition Collaborators)
  - Support and/or leverage initiatives where appropriate
  - Provide visibility across the Department
- Determine action plans for each gap considering:
  - Priority
  - Near Term/Long Term impacts
  - NDIA SW Committee, others, interest in accepting gap(s)
- Engage other communities and participants
  - IT, Business, Research

Over Time:

- Reassess ongoing initiatives against focus area metrics
  - Determine new gaps, or additional effort required to address core issues
- Reassess focus area metrics against systemic software issues
  - From future SW Summits, Systemic Analysis, etc...

Top Software Issues*

1. The impact of requirements upon software is not consistently quantified and managed in development or sustainment.
2. Fundamental system engineering decisions are made without full participation of software engineering.
3. Software life-cycle planning and management by acquirers and suppliers is ineffective.
4. The quantity and quality of software engineering expertise is insufficient to meet the demands of government and the defense industry.
5. Traditional software verification techniques are costly and ineffective for dealing with the scale and complexity of modern systems.
6. There is a failure to assure correct, predictable, safe, secure execution of complex software in distributed environments.
7. Inadequate attention is given to total lifecycle issues for COTS/NDI impacts on lifecycle cost and risk.

***NDIA Top Software Issues Workshop August 2006**

DoD Software -- What We're Seeing*

- Software systemic issues are significant contributors to poor program execution
  - Software requirements not well defined, traceable, testable
  - Immature architectures, COTS integration, interoperability, obsolescence (electronics/hardware refresh)
  - Software development processes not institutionalized, planning documents missing or incomplete, reuse strategies inconsistent
  - Software test/evaluation lacking rigor and breadth
  - Schedule realism (compressed, overlapping)
  - Lessons learned not incorporated into successive builds
  - Software risks/metrics not well defined, managed

*Based on ~65 program reviews to date

The *Integrated Software and Systems Engineering Curriculum Project:* Creating a Reference Curriculum for Graduate Software Engineering Education

Kristen Baldwin and Art Pyster

October 23, 2007

Office of the Under Secretary of Defense
Acquisition, Technology and Logistics
Systems and Software Engineering

Stevens Institute of Technology
School of Engineering
Applied Systems Thinking Institute

Background

- Software drives the performance of virtually all major systems.
- Being able to produce software that can be trusted as reliable, secure, safe, correct, and available while being delivered on-time and within budget is a major challenge for both the government and industry.
- Many steps must be taken to meet that challenge - including ensuring our workforce is well educated in software engineering (SWE) principles and practices.
- Yet today, there is no commonly accepted modern structure or content for graduate software engineering education. Last effort was in early 1990s by the SEI.

iSSEc - The Way Forward

The *Integrated Software and Systems Engineering Curriculum Project (iSSEc)* is creating a reference curriculum leading to a Masters degree in software engineering

iSSEc - The Way Forward

- *iSSEc* is sponsored by DOD and led by Stevens, involving 4 sets of stakeholders:
  - The industrial and government workforce who are the customers of SWE graduate education
  - Academics who provide SWE and SE graduate education
  - Professional societies with a vested interest in SWE and SE graduate education
  - Government organizations who fund improvements in SWE graduate education
- *iSSEc* recognizes that the divide between systems and software engineers in industry, government, and academia works against successfully delivering modern systems in which software is almost always central.
- *iSSEc* will integrate SE principles and practices into the SWE curriculum. The bright line that now separates SE and SWE in academia must be eliminated!

The Approach

1. Understand the current state of SWE graduate education (November 2007)
2. Create a *strawman* model curriculum, suitable for broad use, with a small representative team (February 2008)
3. Publicize effort through conferences, papers, website, etc. (continuous)
4. Gradually obtain endorsement from ACM, IEEE, INCOSE, NDIA, and other professional organizations (continuous)
5. Create full model curriculum, suitable for global use, with a large representative team (September 2008 and September 2009)
6. Seek early adopters (continuous)

Status - Understand Current State

1. Understand the current state of SWE graduate education (November 2007)
2. Create a *strawman* model curriculum, suitable for broad use, with a small representative team (February 2008)
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5. Create full model curriculum, suitable for global use, with a large representative team (September 2008 and September 2009)
6. Seek early adopters (continuous)

Understanding the Current State

- Select diverse set of universities with Masters programs in SWE - vary in size, geography, maturity, resources, target market, ...
- Use Software Engineering Body of Knowledge (SWEBOK) as primary framework for SWE competencies
- Collect data from school websites
  - Degree, faculty size, student population, target market, ...
  - Degree structure, individual course descriptions
  - Map between courses and SWEBOK
- Validate data with professor
- Analyze for commonalities and uniqueness

Schools Completed or In Process

1. Air Force Institute of Technology
2. Brandeis University
3. California State University - Fullerton
4. California State University-Sacramento
5. Carnegie Mellon University
6. Carnegie Mellon University West
7. Carrol College
8. DePaul University
9. Dublin City University (Ireland)
10. Embry-Riddle Aeronautical University
11. Florida A&M
12. George Mason University
13. James Madison University
14. Kingston University (UK)
15. Mercer University
16. Monmouth University
17. Naval Postgraduate School
18. Rochester Institute of Technology
19. Seattle University
20. Southern Methodist University
21. Stevens Institute of Technology
22. Texas Tech
23. University of Alabama-Huntsville
24. University of Colorado - Colorado Springs
25. University of Michigan - Dearborn
26. University of Quebec (Canada)
27. University of Scranton
28. University of Southern California
29. University of Sunderland (UK)
30. University of York (UK)

Some changes still likely

SWEBOK's 10 Knowledge Areas

REQ	Software Requirements
DES	Software Design
CST	Software Construction
TST	Software Testing
MNT	Software Maintenance
CNF	Software Configuration Management
MGT	Software Engineering Management
PRC	Software Engineering Process
TLS	Software Engineering Tools and Methods
QLY	Software Quality

Early Observations from 11 Schools

1. SWE is largely viewed as a specialization of Computer Science - much as systems engineering was often viewed as specialization of industrial engineering or operations research years ago

2. Faculty size is small - few dedicated SWE professors, making programs relatively fragile

3. Student enrollments are generally small compared to CS and to other engineering disciplines

4. Many programs specialize to specific markets such as defense systems or safety critical systems

5. The target student population varies widely - anyone with Bachelors and B average to someone with CS degree and 2+ years of experience

More Early Observations

6. Program outcomes vary widely - software developer to researcher to software manager
7. Wide variation in depth and breadth of SWEBOK coverage in required and semi-required courses
8. SWEBOK alone does not represent the breadth of many program's required courses
9. Some significant topics are rarely mentioned - agility, Software Engineering Economics, Systems Engineering
10. Some topics are ubiquitous - formal methods and architecture
11. "Object-Oriented" is the standard development paradigm - creating a "clash" with many systems engineering programs that emphasize structure methods

Sample Program Specialty

Air Force Institute of Technology	Defense Systems
Embry-Riddle Aeronautical University	Embedded Real-time Software
Naval Postgraduate School	Acquisition of Defense Systems
Seattle University	Project Experience
Stevens Institute of Technology	Quantitative Software Engineering
University of Southern California	Quantitative; Software Economics
University of York (UK)	Safety Critical Systems

Sample Program Focus

Air Force Institute of Technology	Develop professionals to develop and manage increasingly complex software
Embry-Riddle Aeronautical University	How to engineer high-performance sofwtare embedded in aircraft, space and medical systems
George Mason University	Developing and modifying large, complex software systems. Emphasis both technical and management aspects
Monmouth University	Effective member of software development team
Naval Postgraduate School	Enable acquisition professionals to procure highly dependable, trustworthy software-intensive systems
Seattle University	Understand and apply advanced software engineering principles vital to industry
Stevens Institute of Technology	Realizing software products on time, within budget and with known quality
University of Alabama – Huntsville	Provide fundamentals of software development for members of software development teams
University of Southern California	Prepare students for an industrial leadership career in software engineering and serve as introduction to researchers
University of York (UK)	Software systems with a high requirement for dependability.

Sample Target Student

Air Force Institute of Technology	PMs and software developers from DoD & other agencies
California State University – Sacramento	UG degree with CS courses
Embry-Riddle Aeronautical University	Strong academic record
George Mason University	UG degree
Monmouth University	UG degree in CS, SWE or Engineering related
Naval Postgraduate School	Acquisition professionals with 2+ years in software development
Seattle University	UG degree in CS or equivalent 2+ years in software development
Stevens Institute of Technology	Experienced computer professionals seeking leadership positions
University of Alabama – Huntsville	UG courses in CS, math & statistics
University of Southern California	UG degree in CS, math or engineering with courses in computing and math
University of York (UK)	UG degree in CS or related field with math

Introduction to Software Engineering

Schools

AFIT	Air Force Institute of Technology	CSE 481
CSUS	California State University - Sacramento	
ERAU	Embry-Riddle Aeronautical University	
GMU	George Mason University	-
MMU	Monmouth University	SE 504
NPS	Naval Postgraduate School	SW 3460
SEA	Seattle University	
SIT	Stevens Institute of Technology	CS 540
UAL	University of Alabama - Huntsville	CS 650
USC	University of Southern California	CS 577a, CS 577b
YOR	University of York (UK)	-

SWEBOK

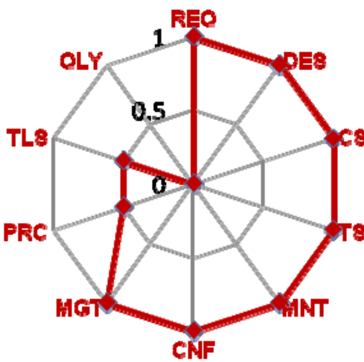
REQ	Software Requirements
DES	Software Design
CST	Software Construction
TST	Software Testing
MNT	Software Maintenance
CNF	Software Configuration Management
MGT	Software Engineering Management
PRC	Software Engineering Process
TLS	Software Engineering Tools and Methods
QLY	Software Quality

Scale

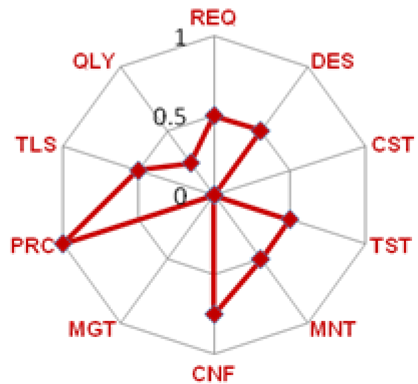
1 .00	**> 90% of subtopics**
0.75	**~75% of subtopics**
0.50	**~50% of subtopics**
0.25	**~25% of subtopics**
0.00	**No Coverage**

Introduction to Software Engineering

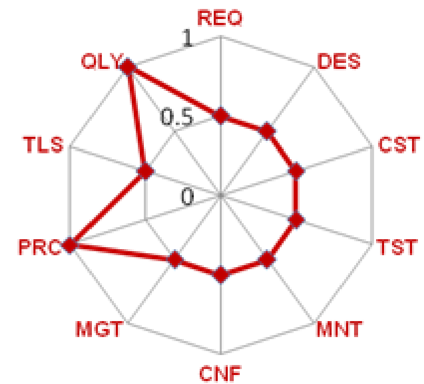
Air Force Institute of Technology



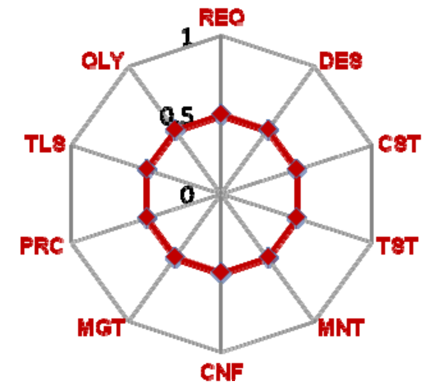
California State University - Sacramento



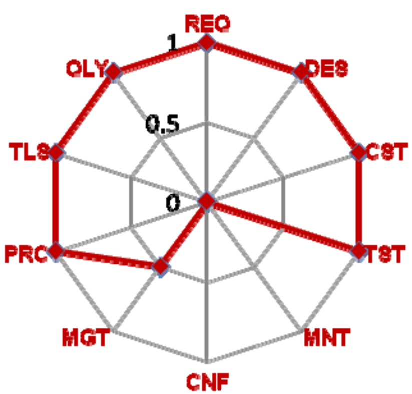
Embry Riddle Aeronautical University



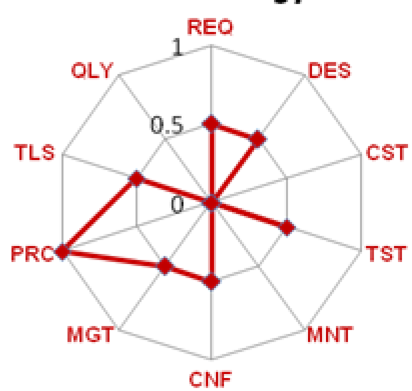
Monmouth University



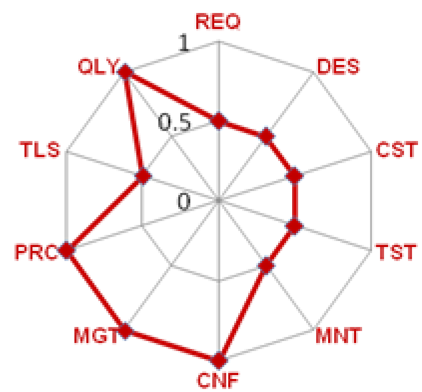
Naval Postgraduate School



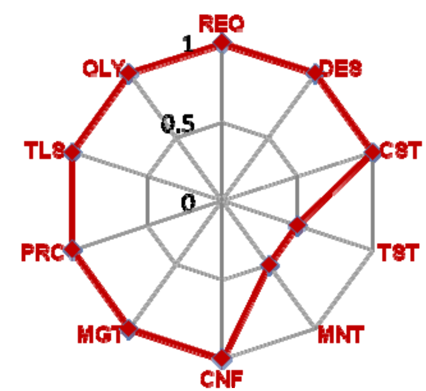
Stevens Institute of Technology



University of Alabama - Huntsville



University of Southern California



1.00 > 90% of subtopics **0.75** ~75% of subtopics **0.50** ~50% of subtopics
0.25 ~25% of subtopics **0.00** No Coverage

Required and Semi-Required Courses

Schools

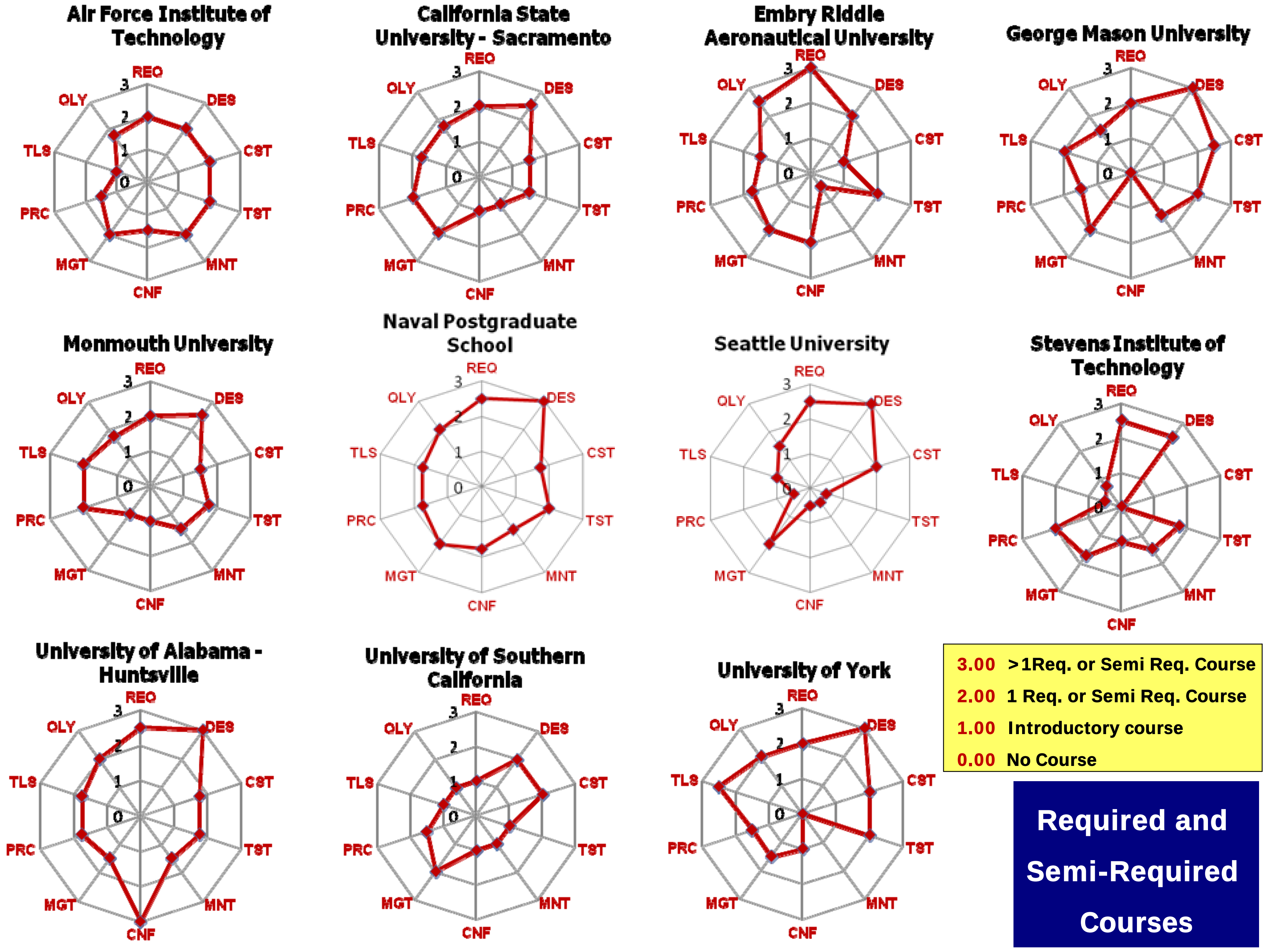
AFIT	Air Force Institute of Technology
CSUS	California State University - Sacramento
ERAU	Embry-Riddle Aeronautical University
GMU	George Mason University
MMU	Monmouth University
NPS	Naval Postgraduate School
SEA	Seattle University
SIT	Stevens Institute of Technology
UAL	University of Alabama - Huntsville
USC	University of Southern California
YOR	University of York (UK)

Scale

3.00	**>1Req. or Semi Req. Course**
2.00	**1 Req. or Semi Req. Course**
1.00	**Introductory course**
0.00	**No Course**

SWEBOK

REQ	Software Requirements
DES	Software Design
CST	Software Construction
TST	Software Testing
MNT	Software Maintenance
CNF	Software Configuration Management
MGT	Software Engineering Management
PRC	Software Engineering Process
TLS	Software Engineering Tools and Methods
QLY	Software Quality


Air Force Institute of Technology
California State University - Sacramento
Embry Riddle Aeronautical University
George Mason University
Monmouth University
Naval Postgraduate School
Seattle University
Stevens Institute of Technology
University of Alabama - Huntsville
University of Southern California
University of York
REQ
DES
CST
TST
MNT
CNF
MGT
PRC
TLS
OLY
0
1
2
3
3.00 >1Req. or Semi Req. Course
2.00 1 Req. or Semi Req. Course
1.00 Introductory course
0.00 No Course
Required and Semi-Required Courses

Non-SWEBOK

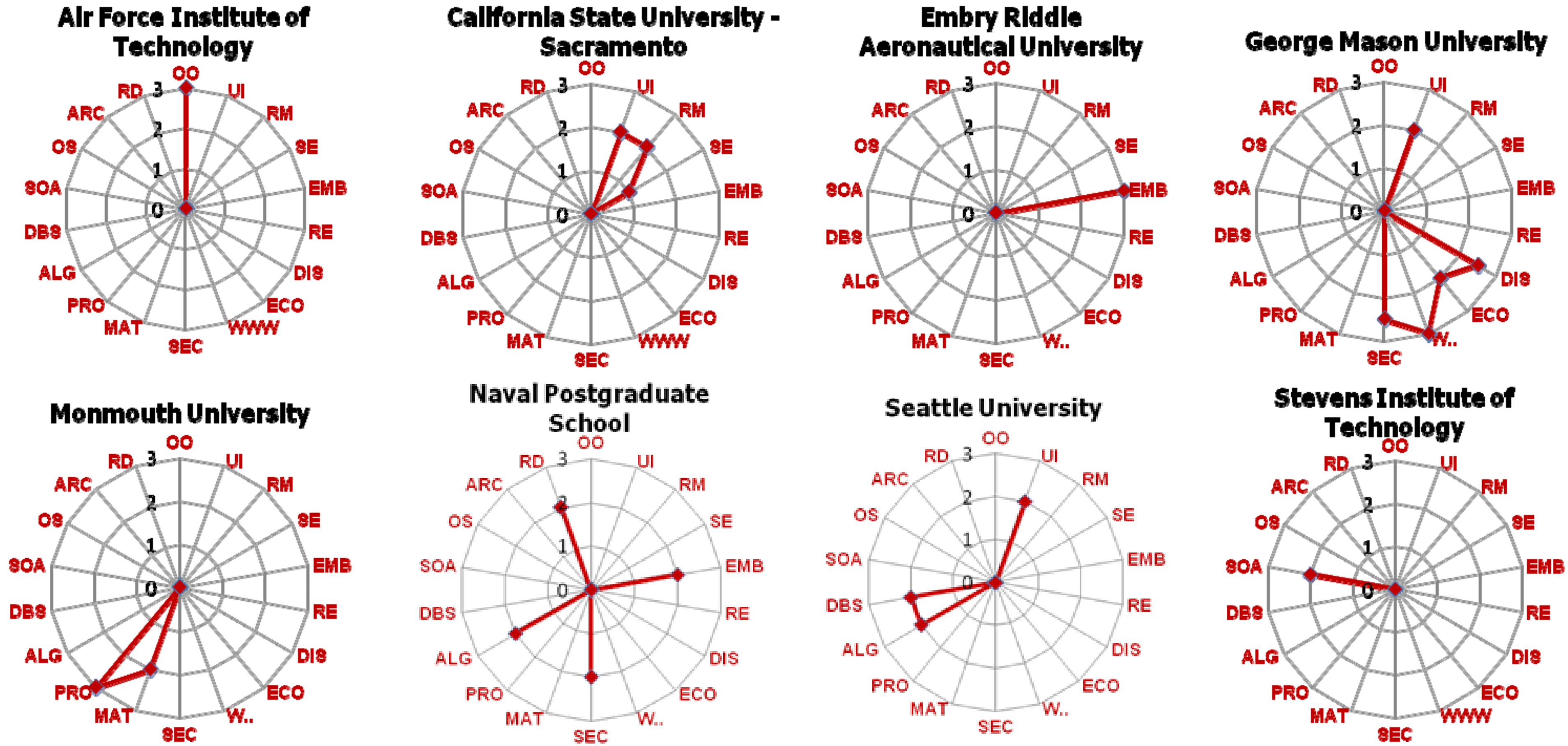
Non-SWEBOK

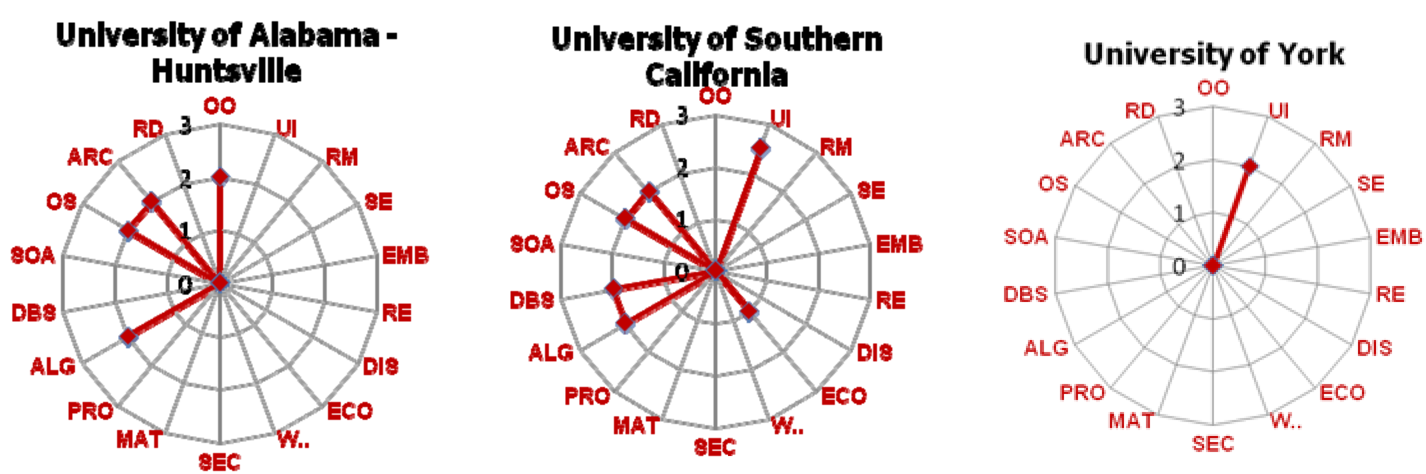
1	OO	Object Oriented Systems
2	UI	User Interface / human computer interaction
3	RM	Research Methodology
4	SE	Systems Engineering
5	EMB	Embedded & realtime software systems
6	RE	Software Reliability
7	DIS	Distributed Software Engineering
8	ECO	Software Engineering Economics
9	WWW	SwE for worldwide web
10	SEC	Software Safety & Security
11	MAT	Math foundations of SwE
12	PRO	Programming
13	ALG	Algorithms
14	DBS	Database Systems
15	SOA	Service Oriented Architecture
16	OS	Operating Systems
17	ARC	Computer Architecture
18	RD	Software R&D

Scale

3.00	**More than 1 full course**
2.00	**Full Course**
1.00	**Partial Course**
0.00	**No Course**

(Required and Semi-Required Courses)

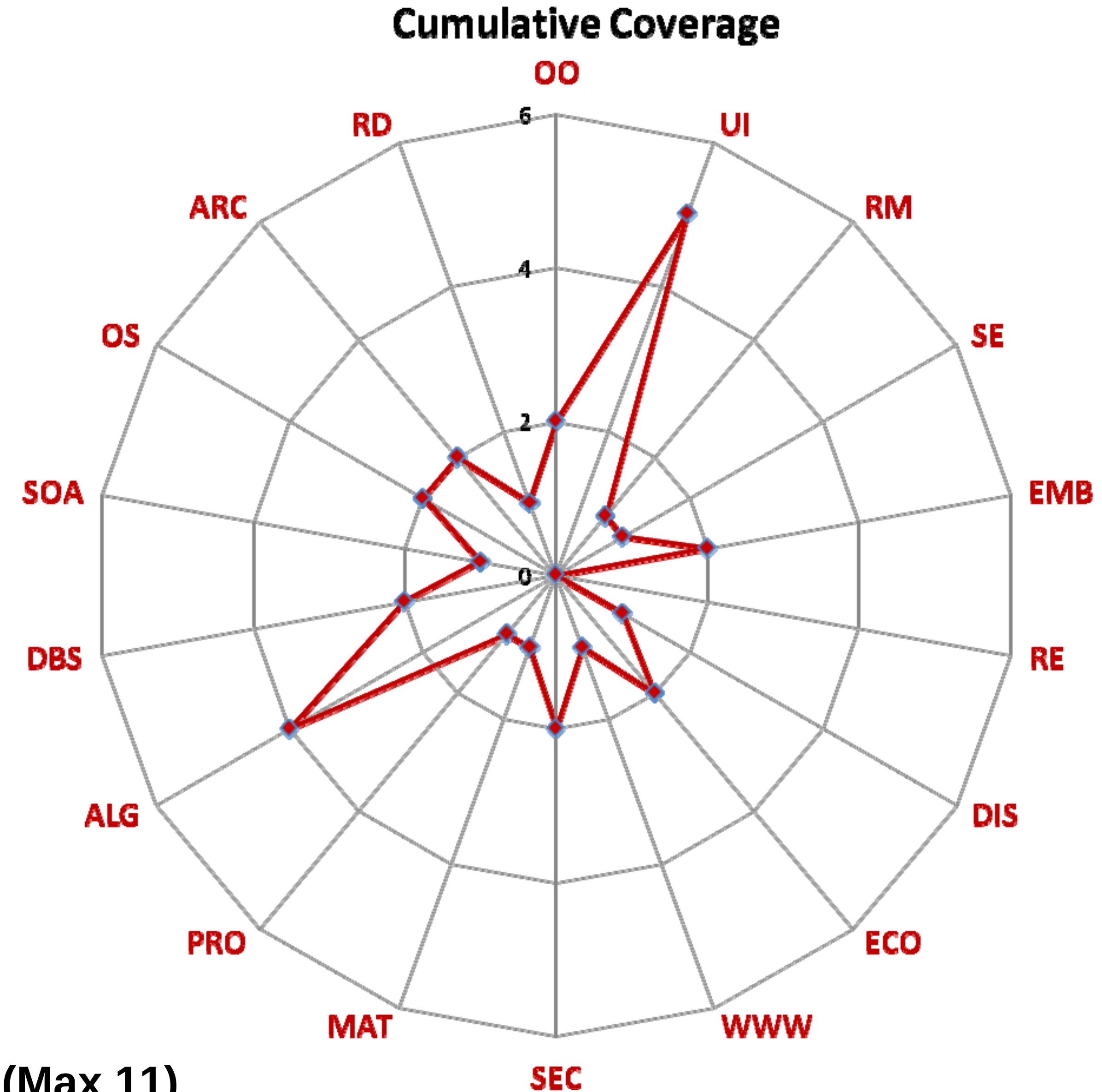




3.00	More than 1 full course
2.00	Full Course
1.00	Partial Course
0.00	No Course

Non-SWEBOK

Non-SWEBOK



MODE
No. of Schools (Max 11)

Early Start Team Members

1. Bruce Amato, *Department of Defense*
2. Mark Ardis*, RIT*
3. Larry Bernstein, *Stevens*
4. Barry Boehm, *USC*
5. John Brackett, Boston University
6. Murray Cantor, *IBM*
7. Robert Edson, *ANSER*
8. Gary Hafen, *NDIA and Lockheed Martin*
9. Tom Hilburn, *Embry-Riddle Aeronautical University*
10. Jim McDonald, *Monmouth University*
11. Ernest McDuffie*, National Coordinating Office*
12. Bret Michael, *NPS*
13. Bill Milam, *Ford*
14. Ken Nidiffer, *SEI*
15. Art Pyster, *Stevens*
16. Paul Robitaille, *INCOSE and Lockheed Martin*
17. Doug Schmidt, *Vanderbilt*
18. Mary Shaw, *Carnegie Mellon University*
19. Richard Thayer, *California State University at Sacramento*
20. Richard Turner, *Stevens*
21. Osmo Vikman, *Nokia*
22. David Weiss, *Avaya*

Graduate Students:
- Deva Henry
- Kahina Lasfer
- Sarah Sheard

Observer:
- Joe Urban, NSF
- Lillian Cassel, ACM

Several more offers and lots of interest…

Status - Create Strawman Curriculum

1. Understand the current state of SWE graduate education (November 2007)
2. Create a *strawman* model curriculum, suitable for broad use, with a small representative team (February 2008)
3. Publicize effort through conferences, papers, website, etc. (continuous)
4. Gradually obtain endorsement from ACM, IEEE, INCOSE, NDIA, and other professional organizations (continuous)
5. Create full model curriculum, suitable for global use, with a large representative team (September 2008 and September 2009)
6. Seek early adopters (continuous)

Creating the Strawman Curriculum

1. Held workshop on August 15-16 at Applied Systems Thinking Institute
2. Reviewed foundational documents: SEI graduate curriculum reports from 1991, SWEBOK, SE2004, INCOSE SE Model Graduate Curriculum
3. Agreed to create strawman curriculum and agreed on outline of document
4. Divided into 4 primary teams with leads from 4 different universities
    - Guidance and Outcomes - Art Pyster, Stevens Institute
    - Curriculum Architecture - Jim MacDonald, Monmouth
    - Body of Knowledge - Tom Hilburn, Embry-Riddle
    - Course Packaging - Brett Michael, Naval Postgraduate School
5. Agreed to work in parallel where possible to speed delivery

Creating the Strawman Curriculum

6. Build Guidance and Outcomes as deltas from SE2004 Principles (Draft 1 done)
7. Build Architecture starting with 1991 SEI curriculum architecture (Draft 1 under review)
8. Build Body of Knowledge as deltas from SWEBOK using INCOSE Handbook, PMI BOK, and current state of SWE graduate programs as primary sources for additions (Draft 1 begun)
9. Build Course Packaging after first three teams have solid drafts
10. Hold second workshop in December to review progress
11. Refine drafts and publish at end of February

Sample Draft Guidance

Software Engineering draws its foundations from a wide variety of disciplines.

- Graduate study of software engineering relies on many areas in computer science for its theoretical and conceptual foundations, but it also draws from other fields, including statistics, logic, calculus, discrete mathematics, formal languages, and other mathematical specialties, from systems and domain engineering, from project and portfolio management, and from one or more application domains.

MSwE2008 must identify prerequisite requirements for students to enter an MSE program.

- Undergraduate computing programs and industry experience in software engineering vary greatly. To help institutions build programs that address the needs of the broad software engineering community, MSwE2008 recommends minimum prerequisite knowledge necessary to successfully engage in a program based on the MSwE2008 curriculum. Generally, that knowledge comes from a technical, scientific, or engineering undergraduate degree including coursework in computer science. However, relevant work experience can substitute for formal education. Schools that wish to admit students lacking that minimum prerequisite knowledge should provide preparatory courses that those students should take before entering the Masters program.

Sample Draft Outcome

Show mastery of the software engineering knowledge and skills, and professional issues necessary to practice as a software engineer in a variety of application domains with demonstrated performance in at least one application domain.

Students, through regular reinforcement and practice, need to gain confidence in their abilities as they progress through a software engineering program of study. At graduation, a student should understand what distinguishes practice in different application domains such as finance, medical, transportation, and telecommunications, should understand how to learn a new domain as needed, and should demonstrate skill as a software engineer in at least one application domain. Such demonstration will include (as defined in Bloom's Taxonomy)

- At least comprehension level competency across all MSwE2008 BOK knowledge areas, not including the KA on "Knowledge Areas of the Related Disciplines".
- Application level competency, or above, in 75% of the MSwE2008 BOK knowledge areas.

Hence, a graduate should be able to analyze, design, verify, validate, implement, apply, and maintain a modest-sized software system and understand the challenges of scaling to larger software systems. In addition, graduates need to have gained an understanding and appreciation of professional issues related to ethics and professional conduct, economics, and the societal needs.

Sample Draft Outcome

Work effectively as part of a team, including teams that may be international and geographically distributed, to develop quality software artifacts, and to lead in one area of project development, such as project management, requirements analysis, architecture, construction, or quality assurance.

Students need to complete tasks that involve work as an individual, but also many other tasks that entail working with a group of individuals. For group work, students ought to be informed of the nature of groups and of group activities/roles as explicitly as possible. This must include an emphasis on the importance of such matters as a disciplined approach, the need to adhere to deadlines, communication, and individual as well as team performance evaluations. Students should have an appreciation of team dynamics and leadership techniques and be able to lead at least one of the areas. Increasingly, teams are assembled from many geographical sites, often across national boundaries. This presents additional challenges of time, language, and culture that students must know how to address.

Status - Obtain Endorsement

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5. Create full model curriculum, suitable for global use, with a large representative team (September 2008 and September 2009)
6. Seek early adopters (continuous)

Endorsements

- NDIA SE Division endorsed *iSSEc* in June 2007
- INCOSE Board of Directors endorsed *iSSEc* in October 2007
- ACM Education Board is following *iSSEc* progress and is considering endorsement
- IEEE Computer Society is following *iSSEc* progress and is considering endorsement
- Endorsement from other organizations is possible

Finally...

- The team working on the Strawman Curriculum has been doing a great job and are keeping to the planned schedule
- A workshop among the broad community to review the Strawman Curriculum and to plan the creation of the full curriculum will be held in March or April 2008 - hope to publish another iteration in September 2008 and another in September 2009 that reflects broad community involvement
- Expect a number of early adopters, including schools represented on the Early Start Team that is building the Strawman Curriculum
- Ultimately, *iSSEc* may create a model curriculum for an interdisciplinary degree that fully integrates software and systems engineering graduate education



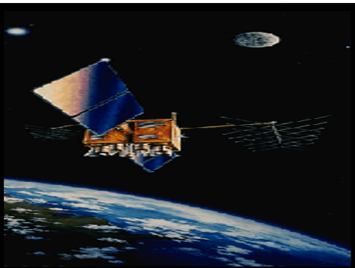

NDIA Conference on Systems Engineering

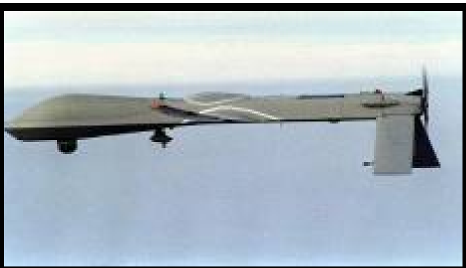
The Honorable

James I. Finley

Deputy Under Secretary of Defense
(Acquisition & Technology)

October 23, 2007




A&T Vision

LEADERSHIP

for an

INTEGRATED, RESPONSIVE

ACQUISITION SYSTEM

providing

WARFIGHTER NEEDS

with

PREDICTABLE PERFORMANCE

"THE WILL TO CHANGE …"

Strategy

RESHAPE THE ENTERPRISE

UTILIZING SHORT AND LONG TERM

INITIATIVES

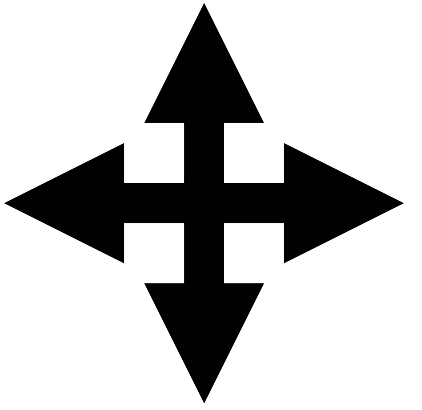
THAT

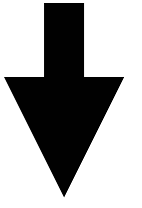
ACCELERATE LASTING CHANGE

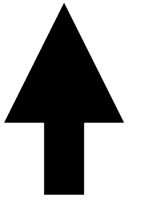
FOR ALL ELEMENTS OF THE

ACQUISITION SYSTEM

Goals

- Communication 

- Cycle Time 

- Competitiveness 

Impact of Not Starting Programs Right

My observations since last year...

- Programs usually fail because we don't start them right:
  - Requirements instability/creep – not well defined, not understood
  - Inadequate early technical planning
  - Inadequate funding or phasing of funding to properly execute the program
  - Lack of schedule realism – success oriented, concurrent, poor estimation/planning
  - Lack of technical maturity or a credible back-up plan – "we're always optimistic"
  - Limited focus on life cycle issues

Program success depends on rigorous, thorough, technical planning and supportive resources

Balanced, Early Life Cycle Planning

- Acquisition strategy – realistic, effective, and executable
- Cost estimate – accurate
- Integrated technical planning (SE / T&E / SW / 'ilities)
- Technology identification and maturity
- Supportive business rules (RFP, contract, etc.)
- Entrance / Exit criteria at each milestone
- Risk identification / mitigation
- Increased Competition and Prototyping

Requires disciplined leadership to stick with the plan

What we need from you…

- Tell your leadership that Dr. McQueary and Dr. Finley are focused on starting programs right!
- We are working daily to improve communication, both in DoD and with Industry
- We are looking to improve competition and time to field capabilities

... Q&A ...

We owe them our very best!!!

Headquarters U.S. Air Force

I n t e g r i t y - S e r v i c e - E x c e l l e n c e

Status of USAF Systems Engineering

Mr. Terry Jaggers, SES
Deputy Assistant Secretary
Science, Technology, & Engineering

23 Oct 2007

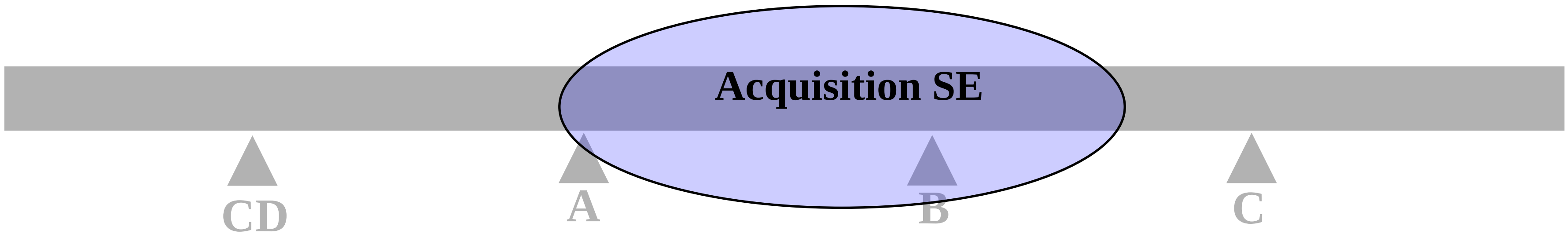
What We've Done…

- Published AFI 63-1201, Life Cycle Systems Engineering (LCSE) -- first AF policy for SE
- Published AFMCI 63-1201, OSS&E and Systems Engineering Life Cycle Management
- Life Cycle SE initiatives pushed into all AFSO21 initiatives for which SE is a key enabling process
- Created Unit Compliance Inspection (UCI) checklist for SE at AFMC
- Creating integrated Weapon System Integrity Program to ensure cohesive SE effort with all integrity programs
- Developing AFMC-wide Risk Management Tool pilot
- Begun insertion of SE practices into Probability of Program Success (PoPS) management tool
- In final steps of ensuring 100% SEP compliance across all air and space ACAT programs to meet SECAF direction
- Increased workforce participation in SE graduate education and distance learning programs
- Completed National Research Council (NRC) study on early SE
- Funded SMC pilot project to develop and validate process documentation -- report ECD Nov 07

Where We're Going…

- Developing a Corporate AF SE Assessment Module to support core SE attributes across both AFSPC and AFMC – process areas, process area goals, practices, and evidence
- Including an AFIT SE Masters' Degree program in Civilian Developmental Education
- Investigating governance framework for enterprise architecting and system-of-systems (SoS) engineering at CSE
- Increasing academic research (in-house & collaborative) at AFIT CSE
- Enhancing integration of related specialty areas (software, HSI, manufacturing, etc.) for inclusion in increment 2 of AFI 63-1201
- Establishing an AFMC knowledge management toolset or forum to assist programs with issues in planning or executing SE
- Preparing a study to review best practices from TRAs, MRAs, IPAs, PSRs, IRTs, etc. as a Corporate AF gold standard for deep dive tech planning reviews
- Refining policy, processes, programs and people issues to implement early SE under the Life Cycle Systems Engineering (LCSE) construct

What is AF Life Cycle Systems Engineering (LCSE)?



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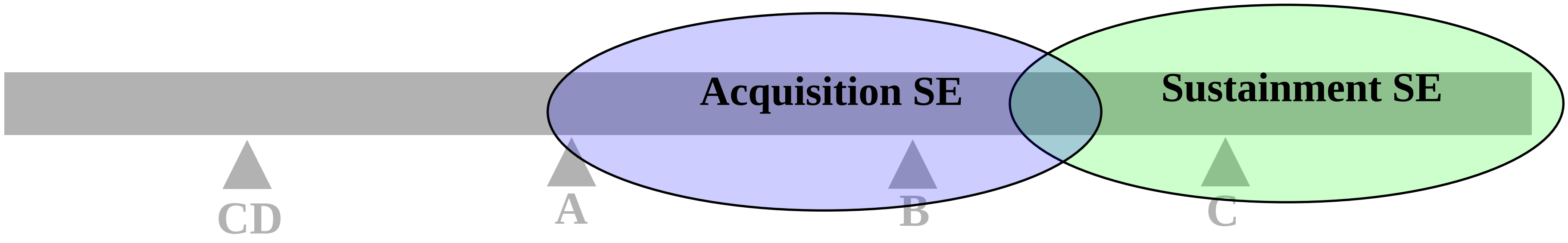

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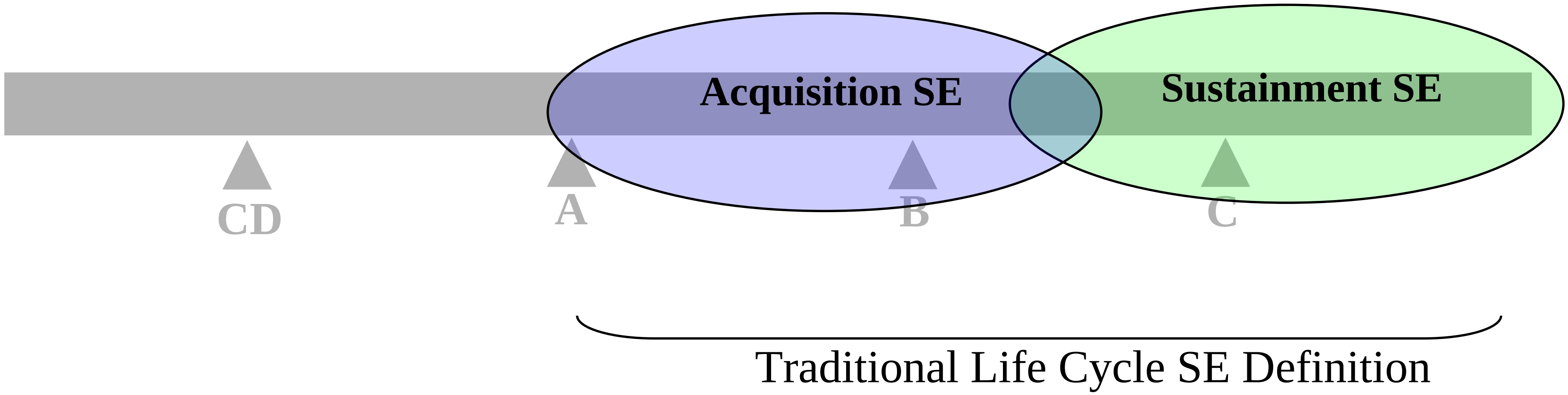

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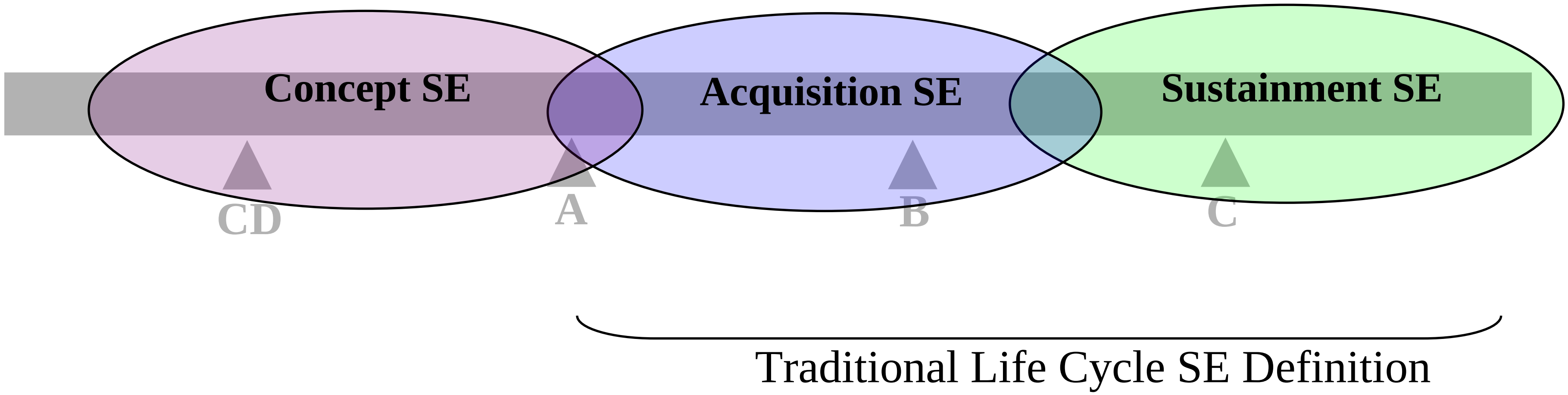

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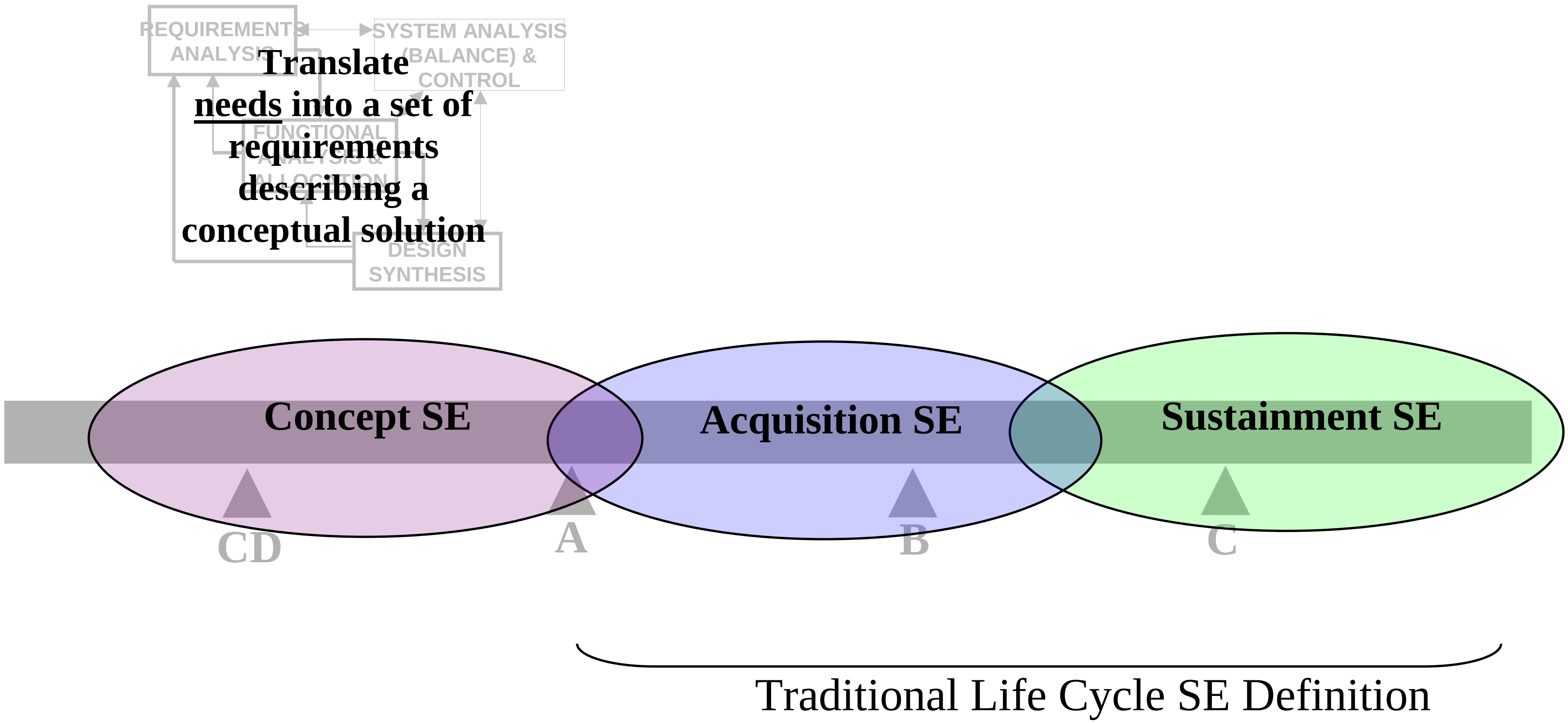

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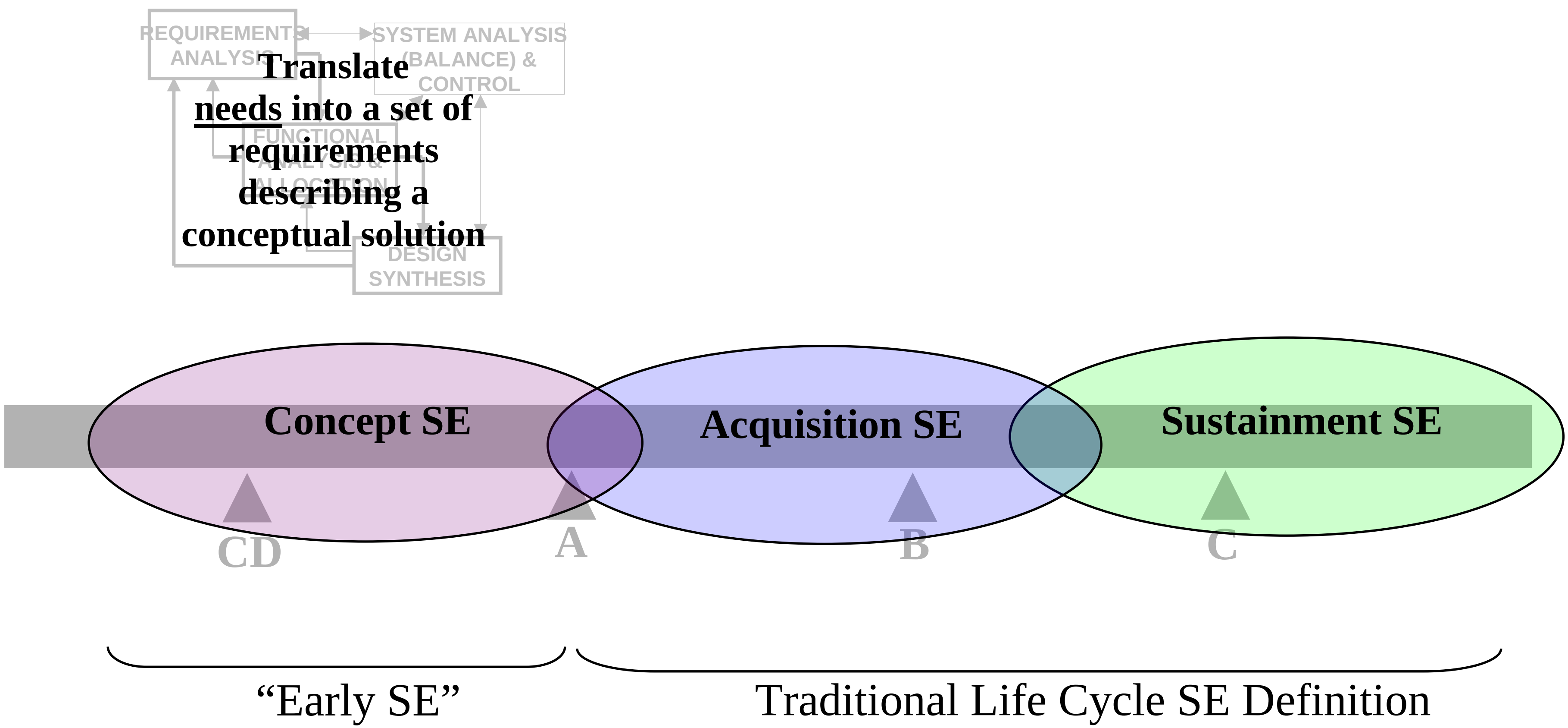

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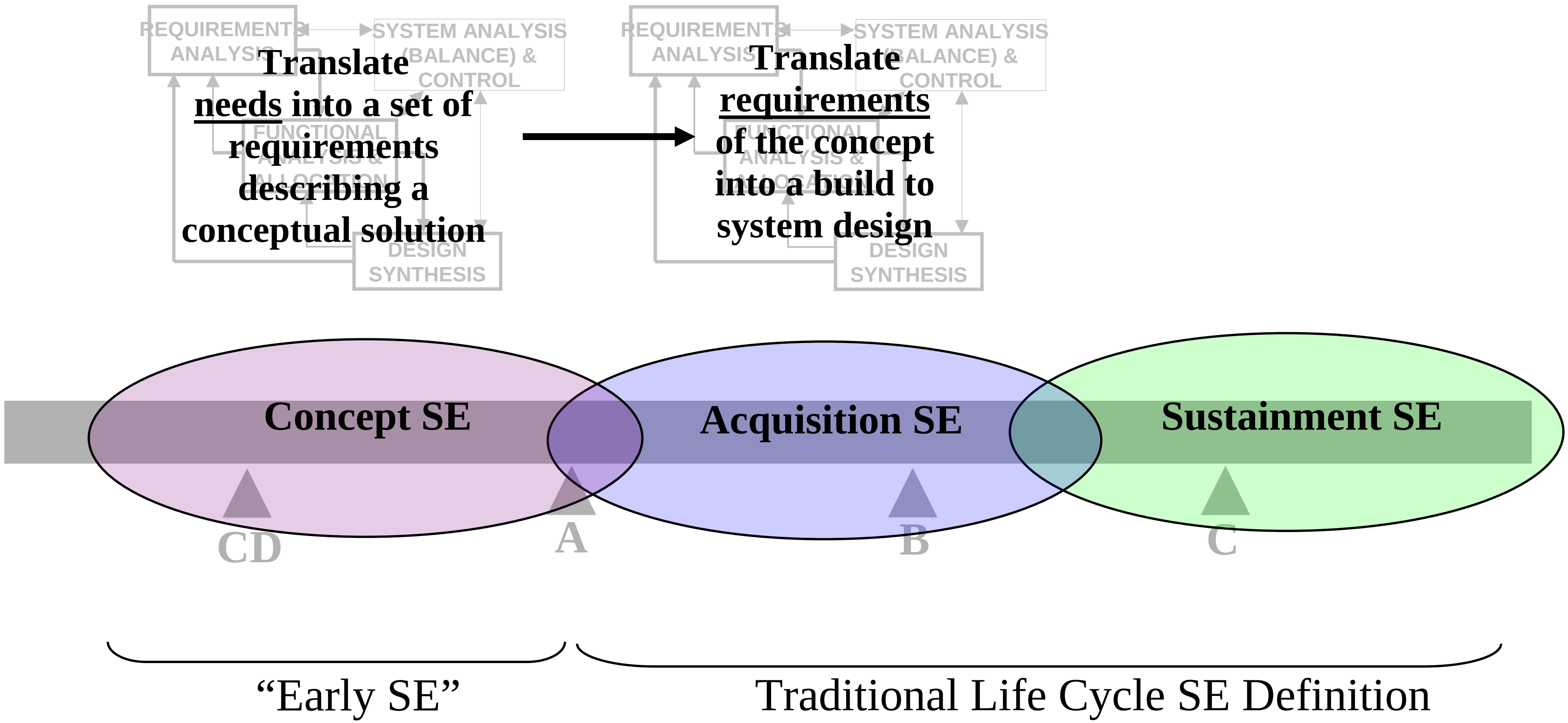

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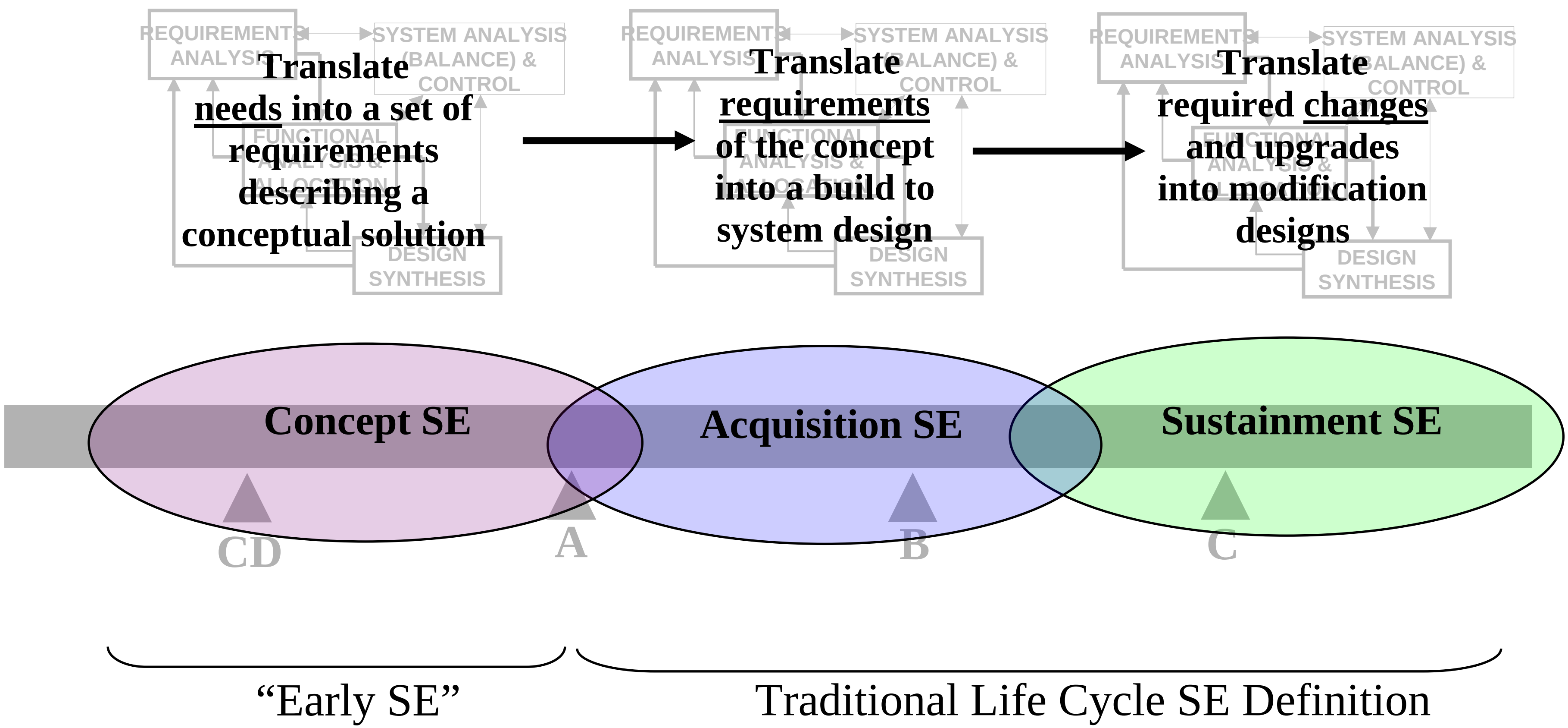

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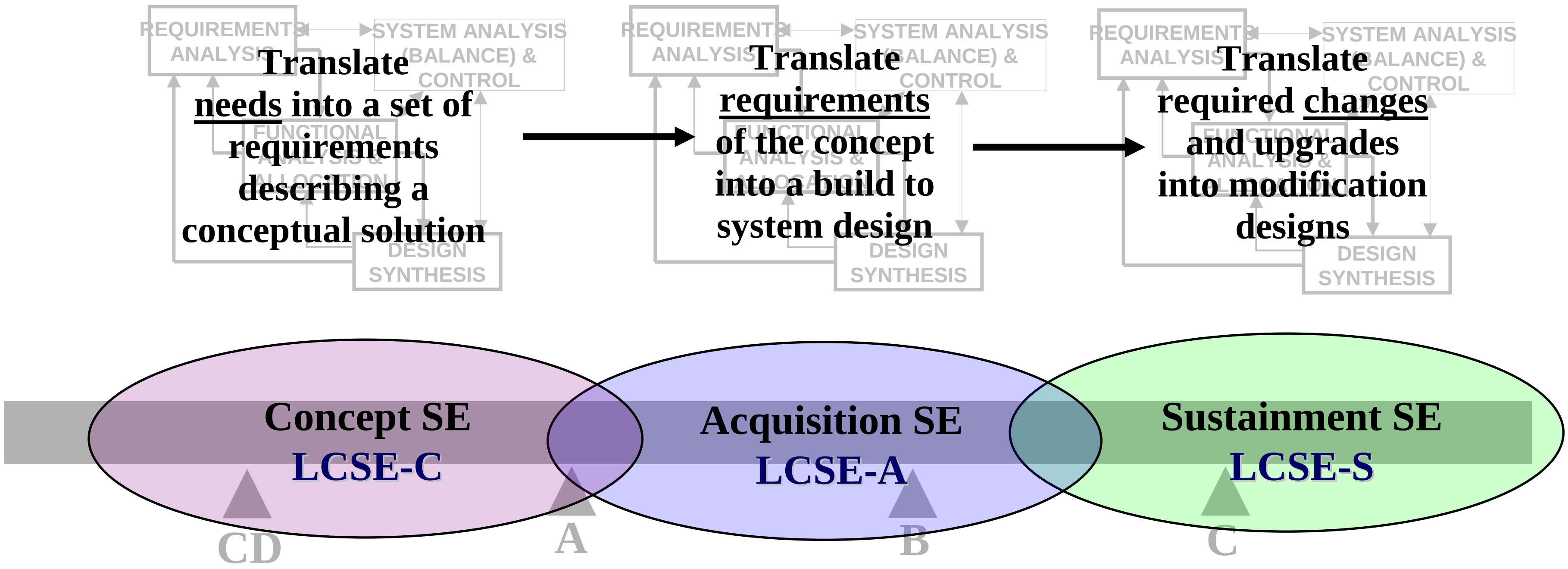
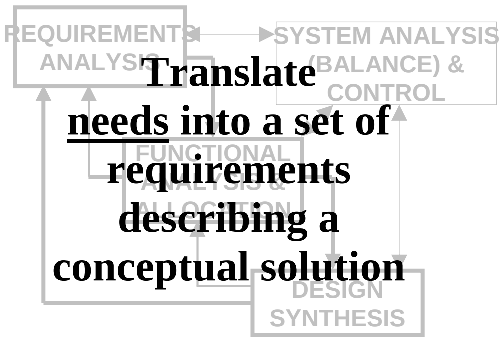


"Early SE"

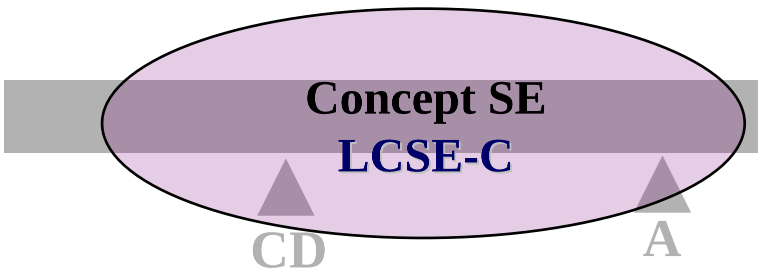
Traditional Life Cycle SE Definition

LCSE Defined by Air Force Instruction (AFI 63-1201)

What is AF Life Cycle Systems Engineering (LCSE)?



Translate <u>needs</u> into a set of requirements describing a conceptual solution



- Like a SEP, the SE process during the LCSE-C phase is governed by a "concept engineering plan" or a (ConSEP)
- Like the System Design Spec, the product of the LCSE-C phase is a concept design or a "concept characterization"
- Like verification of the system design, the concept characterization needs verification & traceability

Early SE leads to better military utility assessments & better life cycle cost estimates, which inform decisions & ultimately lowers risk during acquisition

Early SE Challenges

Policy

- Establishing formal milestones earlier
- Establishing criteria to measure early SE products at these milestones

Process

- Developing ConSEP guides
- Templates for Concept Characterization documents
- Capturing SE content in IT to move forward with programs

Programs

- Institutionalizing funding for consistent SE application
- Placing early concept SE products under configuration control

People

- Identifying early SE expertise & “systems thinkers”
- Ensuring the right balance between engineers & analysts, military & civilian

Summary

- AF Making Progress in SE Revitalization
- AF Will be Resource Constrained in the Future
- Early SE Provides Opportunities to the AF

Pursuing USAF Technical Excellence!

Special Thanks

Col Jim Horejsi

Col Rich White

Maj David Borgeson

1st Lt Steve Dirks

and the SMC Team

Great Work on the Pre-A SE Process (PASEP) Study

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A Test Strategy Done Early Drives Test Planning and Successful Testing

National Defense Industrial Association (NDIA)
10th Annual Systems Engineering Conference
October 22-25,2007

Test & Evaluation in Systems Engineering Track,
Tuesday October 23, 2007

William Lyders, ASSETT Inc.

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Agenda

- T&E Strategy, an important early document in the SE Process
- Key Information: Contents in a T&E Strategy
- Where the Features of a Test Strategy are Verified
- T&E Lessons Learned at ASSETT
- Summary and Conclusions
- Q&A

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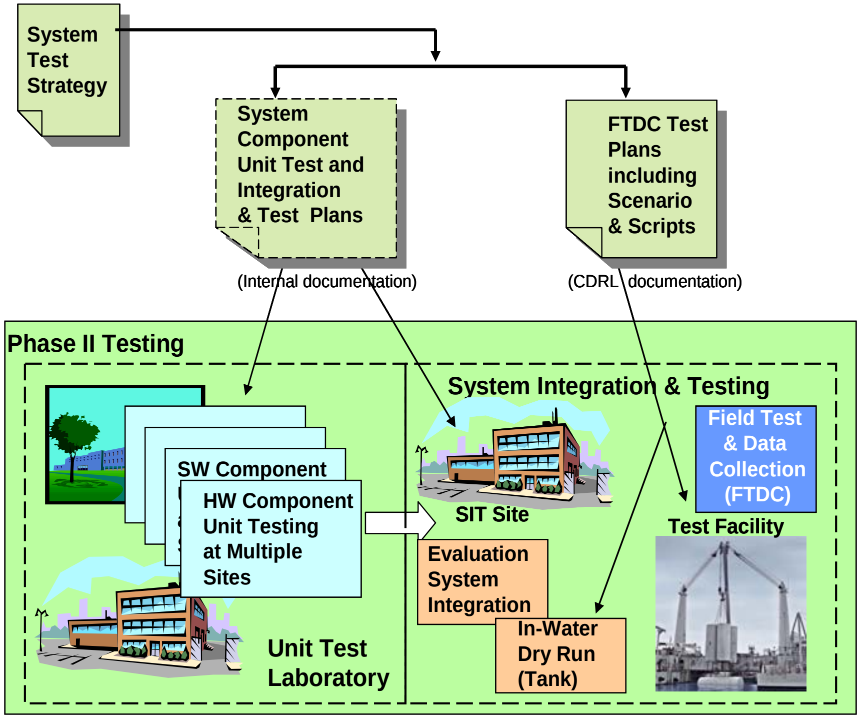
A Test Strategy Sets the Stage for Testing

- Test Strategy is a high level description of major system wide activities that achieve the project’s testing objectives
- It outlines the approach to ensure the system is adequately tested
- Ground rules for writing the Test Plan
- Done early in the life cycle, it is a generic approach and defines the basis for test plans and test procedures to follow.
  - Sometimes features done with proposal
  - Should complete by PDR

One early Strategy is to define the Test Environment Locations for Test Events



T&E Strategy, an early SE Process product

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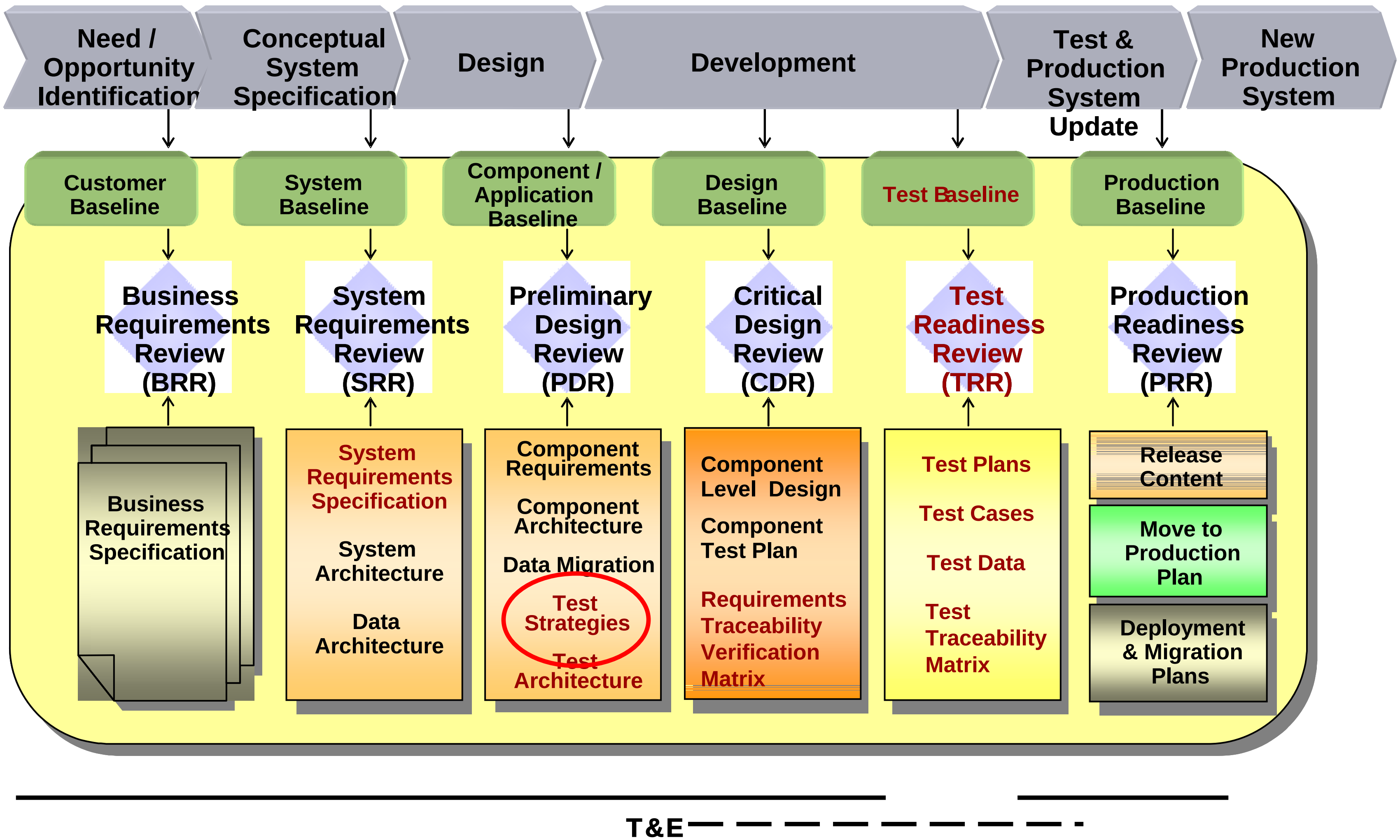
The features of a Test Strategy should all be baselined by the PDR



Key Information: Contents in a Test Strategy

Table of Contents

Contents: Test Scope & Objectives

Bounding the amount of Testing early is a key test program planning objective

Test Scope

- **Define boundaries of test – a test work flow**
- **Contractual limitations**
- **Lists of applicable system components planned in tests**
- **Emphasis on a cost effective, team approach**
- **SOW emphasis on specific efforts to verify technical requirements and limit risks**

Testing Objectives

- **Clearly define overall project technical objectives**
- **Define the multiple levels of testing within the test scope**
    - **Laboratory**
    - **Field Test**
    - **Test Platform**
    - **Operational**
- **Technical objectives for each level of testing**
- **Customer objectives and importance**

Contents: Assumptions

For your efforts

The key and critical underlying assumptions behind test strategy

For your team & customer

Test Environments

- Locations of different test environments
- Infrastructure requirements
- Simulation/Stimulation fidelity
- Development and T&I environment HW/SW
- Owners and maintenance responsibilities
- Sharing of components between environments

Test Operations

- Company/organizations testing each component
- Hardware/Software delivery schedule and methods
- Planning and conducting DT& E (T&I) and OT&E
- Plans for incorporation of OT&E early in cycle
- Test teams by company and test event
- Field testing and Customer site acceptance tests
- Discrepancy level definitions – PTR Severity
- Regression testing

Test Documentation

- Information Level & Product Schedule
  - Components
  - System T&I
  - Test Plans
  - Test Procedures
  - Test Reports
  - Test Data

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Contents: Risks and Critical Attributes

Risks to successful testing should be assessed with mitigation plans

Risk #	Risk Description	Probability (H, M, L)	Priority (H, L, M)	Mitigation
1	IF the Cabinet Components for the First Article TPS Cabinet do not arrive or are not accepted per the IVT start date THEN the Cabinet IVT will not be able to start on time.	M	M	The Cabinet components ordered for the Prototype required a longer lead time than originally expected. So the FA components are being ordered earlier than originally planned.
2	IF the Cabinet Integration is not successfully completed by January 4, 2008 so the Certification Test can be completed by 22 January, 2008 THEN the Cabinet cannot be shipped to the Prime and their Integration of the Cabinet will be impacted.	M		ASSETT is investigating advancing the component purchasing plans to be able to have the Cabinet components 1-2 months earlier. This could allow a 1-2 month earlier start for Cabinet Integration. Also the planned test time for IVT includes some buffer time for unexpected problems.

Example

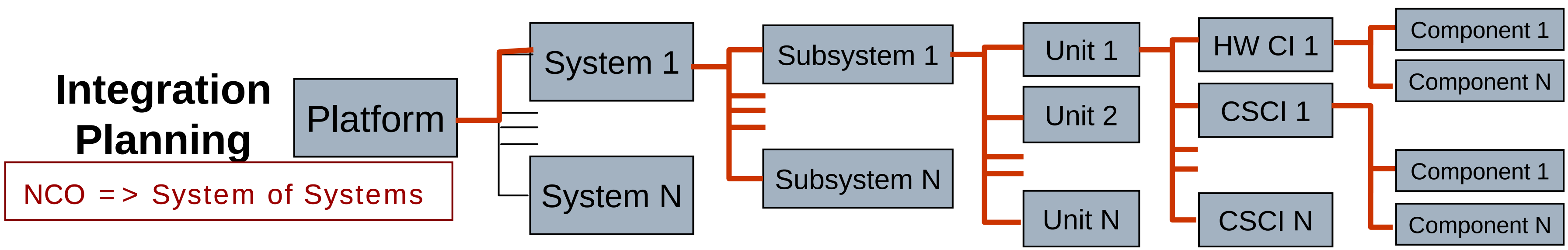
Test Focus areas or the Critical Attributes of the system that must be tested to provide the customer's level of confidence in the system

Examples of critical attributes:
- System thru put
- Ability to handle specific data types
- Ability to support legacy interfaces
- Ability to be maintained
- Reliability if a very high reliability is necessary
- Performance
- Support operational situations

Examples

Contents: Plan Strategies for each Level of Testing

The System Integration Planning Strategy Must Address All Levels of Test & Leverage the Coverage at Each Level to Eliminate Duplication



- Levels of Planning
  - Platform
  - System
  - Subsystem
  - Unit/Program
  - Configuration Item
  - Component
  - Field Test
- Results in Multiple Test Plans

System Test Strategy

- Acceptance Criteria for each system requirement is identified.
- Test Strategy for each system requirement is established.

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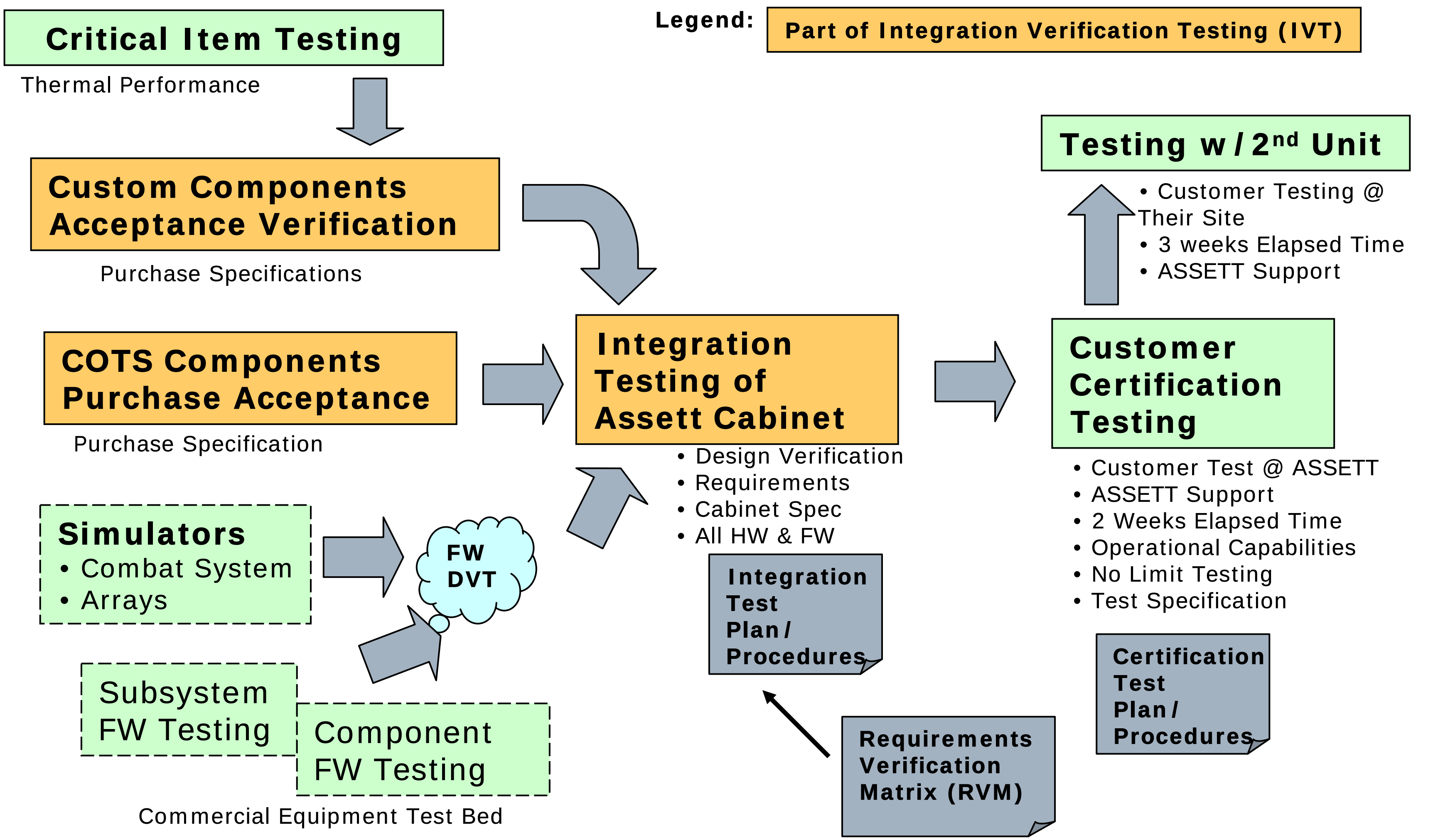
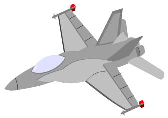
Example Test Level Strategy Work Flow

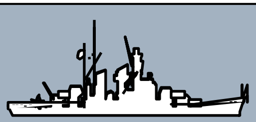
Create a flow diagram of planned test activities to visualize schedule & overlaps



Contents: Types of Testing and Strategies

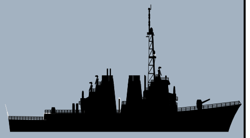


The Types of Testing can be planned for by the types of requirements

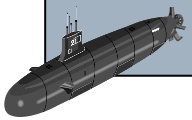


- **Test Planning by Types**
  - **Functional:**
    - **Business Functions, System Functions,**
    - **System Performance, Interfaces. etc.**
  - **Non-Functional:**
    - **Construction, Shipping, Environmental, RMA, etc.**

- **Schedule Driven vs. Event Driven Strategies**
  - **Event Driven Testing**
    - **Event driven best for reducing technical risks**
    - **Only advance when lower level of technical verifications are completed**
      - **Component, Unit, Cabinet or Computer Program, …. System**
    - **Can be more expensive if delays in Subsystem or System level testing impacted**
  - **Schedule Driven Testing**
    - **Rigorous schedule of testing to consider funding profile**



- **Integrating DT&E Events with early OT&E Events**
  - **DT&E is Laboratory level testing – little or no human environment**
  - **DT&E uses simulators for operating environment conditions**
  - **OT&E includes the human element in testing**
  - **OT&E has the real platforms and real operating environments**
  - **Early OT&E Alignment in DT&E environment can be done**
    - **Plan long duration operability demonstration tests with real system operators**
    - **Schedule regular test shifts for 3-6 months for real system operators**



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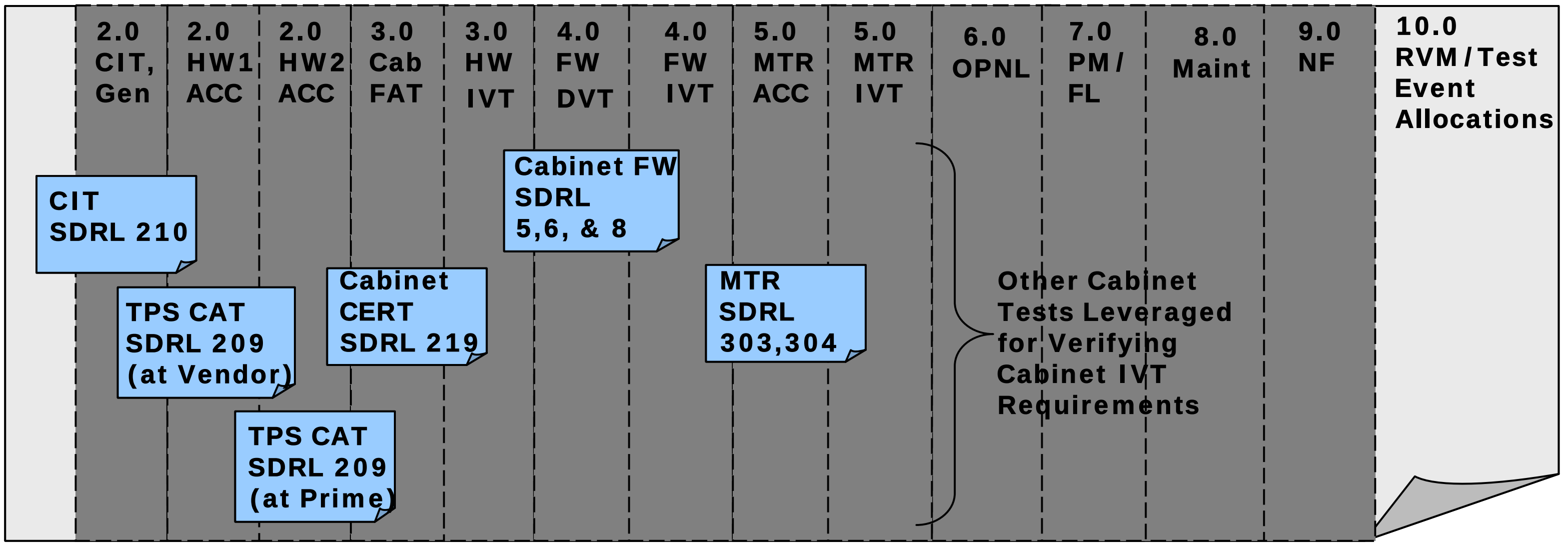
Contents: A Test Procedure Strategy and Test Methods

Strategy: Consider leveraging early requirement verifications for integration testing



Strategies for which Test Methods to later be defined for each requirement or use case need to be identified early

- **Analysis** (A) – Verification by analysis includes quantitative proof that an item meets the requirement by the technical evaluation of equations, diagrams, or representative data.
- **Demonstration** (D) – Verification by demonstration includes exercising an item to provide qualitative data that an item meets a requirement.
- **Hierarchical** (H) – These requirements contain no significant content but are used to establish a hierarchical relationship between requirements. They are verified by the verification of their subordinate requirements. (Does not require a test)
- **Inspection** (I) – Verification by inspection includes examination of hardware or documentation to see if an item meets the requirement.
- **Similarity** (S) – Verification by similarity includes a comparison of one item to another item that has been verified to meet the requirement.
- **Test** (T) – Verification by test includes using an instrument to make a measurement that provides qualitative data that an item meets the requirement.

Contents: Organizational Responsibilities, Criteria

Consider the expected Test Organizations and their Responsibilities in your plans

Role/Responsibility	Name/Organization	Phone number
ASSETT Test Director	Bill /ASSETT	800-555-1234
ASSETT Hardware Tester #1	Patrick /ASSETT	800-555-4567
ASSETT Hardware Tester #2	Monty /ASSETT	800-555-6789
ASSETT Firmware Tester #1	Rob /ASSETT	800-555-1357
ASSETT Firmware Tester #1	Rod ASSETT	800-555-2468
Customer Witness #1	Witness #1/EDO	
Customer Witness #2	Witness #2/EDO	

Define Specific Success Criteria in order to Enter & Exit Test Events and Levels

- **Entry Criteria**
  - **Establish pre-requisites before starting any series of test events**
  - **Example: testing of a work product at the previous level completed**
  - **Example: No significant PTRs**
- **Exit Criteria**
  - **Establish post-conditions before declaring completion of test events**
  - **Agree on Pass/Fail Criteria, e.g. statistical performance testing; reruns**
  - **Example: Customer accepts work product**
  - **Example: Acceptable level of each open Discrepancy level (PTRs)**

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Other Contents (Page 1 of 2)

Test Equipment

- Technology needed in test environments
- Determine what will be bought, GFE, CFE, capitalized
- If field tests involved, determine transportability

Test Metrics

- Metrics programs or measurement strategy
- Metrics could drive test method scope and equipment needed

Test Management and Reporting

- T&E Manager, Test Director, and organization
- Approach to reporting daily & final test results
- Capturing, tracking and reporting discrepancies (PTRs) against requirements
- Test Reports

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Other Contents (Page 2 of 2)

- **Approvals**
  - **How are tests to be witnessed**
  - **How are test results and test reports approved**
  - **What constitutes a successful completion by your customer**

A Glossary of abbreviations for the project is very helpful in understanding terminology

AIS	Active Intercept Sonar	PCA	Physical Configuration Audit
BCR	Baseline Change Request	PCI	Production Control Inspection
CAS	Cylindrical Array Sonar	PI	Production Inspection
CAT	Component Acceptance Test	PRS	Passive Ranging Sonar
CC&S	Combat Control and Surveillance	POC	Point of Contact
CI	Critical Item	PTR	Project Trouble Report
CIT	Critical Item Testing	QA	Quality Assurance
CDR	Critical Design Review	QMP	Quality Management Plan
CDRL	Contract Data Requirements List	RVDS	Requirements Verification Data Sheet
CMP	Configuration Management Plan	RVM	Requirements Verification Matrix

Some DT&E & OT&E Lessons Learned at ASSETT

- **Get testable requirements and test pass/fail criteria defined early and agreed upon with the Customer**
- **Create a Test Strategy and Master Test Plan**
  - **Get buy in by all parties involved**
- **Prepare Test Plans for each of the different levels of integration and conduct peer reviews and customer reviews as necessary – don't want surprises at acceptance**
- **Create a SRVM and get it reviewed/approved**
- **Fully dry run all test procedures**
- **Document all test findings and share them with both Customer and own teams**

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Test Strategy Contents: Agreement & Verification done at Different SE Milestones

Proposal / SRR Milestone	PDR Milestone	CDR Milestone	TRR Milestone
Scope	-	-	-
Test Objectives	Test Objectives	-	-
Assumptions	Assumptions	-	-
	Risk Assessment	Risk Assessment	-
	Critical Attributes	Critical Attributes	-
		Types of Tests	Types of Tests
		Test Methods	Test Methods
		Organization	Organization
			Entry / Exit Criteria
			Test Equipment
			Test Management
			Test Reporting
			Approvals
☐ Proposal ☐ System Requirements Specification	☐ Test Strategies ☐ Test Architecture	☐ Requirements Traceability (SRVM)	☐ Test Plans ☐ Test Procedures ☐ Test Data ☐ Test Traceability

Summary & Conclusions

1. **An initial Test Strategy should be completed very early in the SE Process…often in the proposal!**

2. **More detailed Test Strategy Contents can be defined and refined in later SE Phases in Test Architectures, Test Plans, & Test Procedures**

3. **Test Strategy Features are agreed upon early and verified at design reviews and test readiness reviews during the SE Process**

Systems Engineering provides a structured approach to managing the technical solution over the full life cycle from concept to deployment to retirement…

…Test and Evaluation complements this approach with support for defining requirements and integration planning…and conducting many levels of integration tests with systems engineering support to achieve customer acceptance of a system…

Q&A

Abstract

Successful test and evaluation (T&E) starts at the beginning of the SE process by defining testable requirements and a test strategy for verifying those requirements. A Test Strategy is a high level view of a project's Test Plan and the necessary Test Equipment Support. The SE defines the test strategy, implements it in test plans & test procedures, and then supports the T&E team doing the testing. This presentation will identify lessons learned and how ASSETT Inc. has successfully defined test strategies for both large and small projects for military systems both with/without integrated commercial components.

<u>The T&E Strategy is an important early document in the SE Process:</u> The T&E Strategy is a high level description, developed prior to PDR, of major system-wide activities to achieve the testing objectives. It outlines the planned approach to ensure the system is tested adequately. An event-drive test program is recommended over a schedule driven test program to reduce technical risk. A transition of developmental tests (DT) with operational tests (OT) is recommended.

<u>The Key information in the T&E Strategy:</u> A Test Strategy, whether in a stand-alone document or incorporated into a project Test Plan, defines the testing objectives, assumptions, an initial project risk assessment, test focus areas, the different levels and types of testing, the test organization responsibilities, entry/exit criteria for the different testing levels, test tools, and any metrics relevant to project quality criteria. A brief explanation and the importance of each of these will be summarized.

<u>Where the Features of a Test Strategy are verified:</u> At the PDR where a Test Plan is presented, the features of a test strategy begin to be verified. The plans for validation of stakeholder requirements, test time and resources, and planned tests and accompanying test procedures are reviewed. These features are again reviewed in more detail at the CDR. And finally, at the TRR prior to starting the test, the requirements traceability and test resources (tools, procedures, limitations, and validity of the test procedures) are confirmed.

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Session: Test and Evaluation in Systems Engineering

Author Biography – Mr. Lyders has over 37 years of both systems engineering and project management experience in both federal software and commercial Information Technology (IT) development projects. He has significant complex system test and integration expertise developed through his federal work with multiple Sonar, Combat Control, and Submarine Combat Systems and multiple SBIR projects for the Navy. He was also the Test Team Lead on large commercial projects for both domestic and international financial institutions. Mr. Lyders is currently Lead Systems Engineer and Test Director on two projects at ASSETT. Mr. Lyders is also a member of both NDIA and INCOSE.

OPERATIONAL TEST AND EVALUATION • DIRECTOR •

WEAPONS THAT

KEY TO

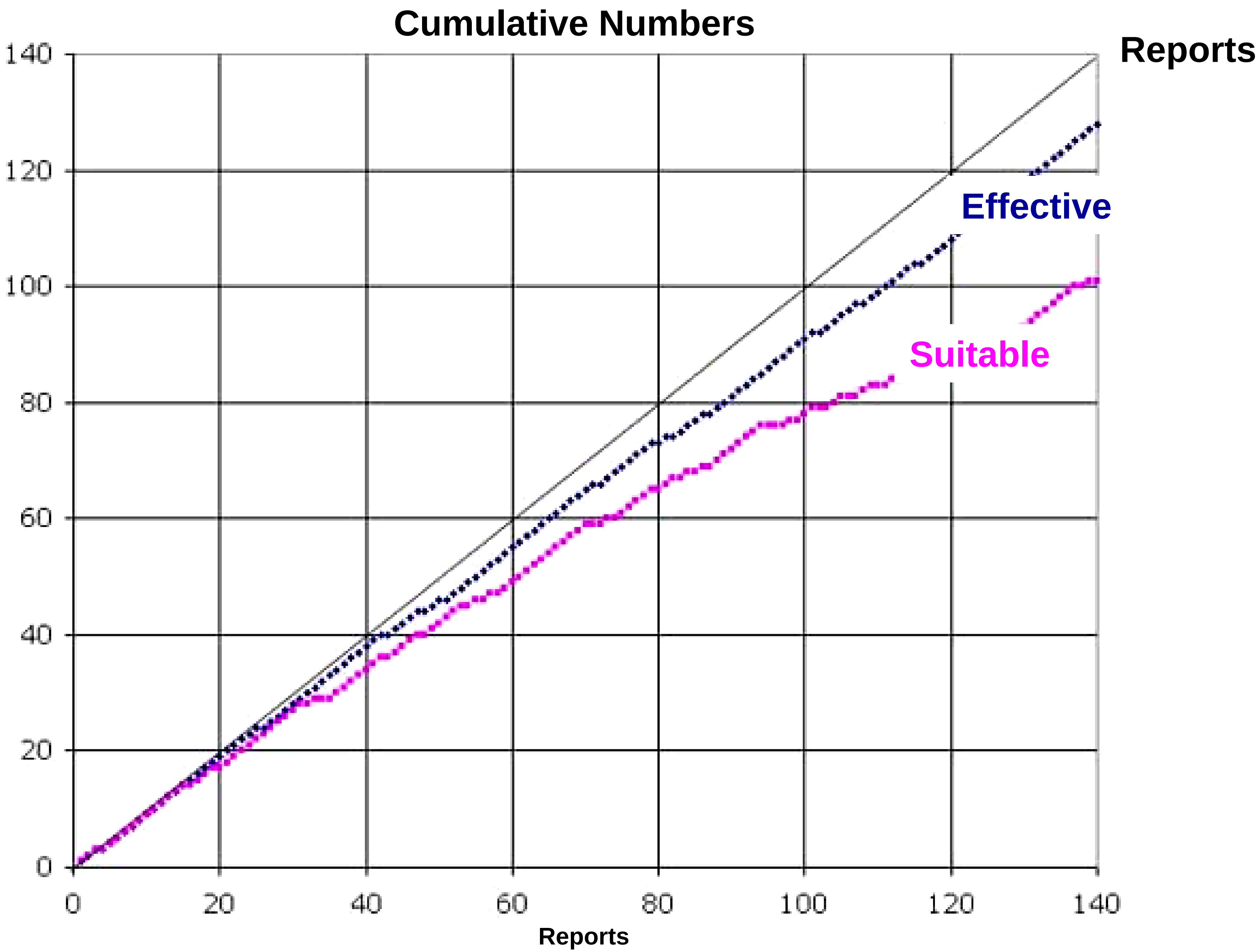
WORK

Improving System Reliability Through Better Systems Engineering

23 OCT 07

Dr. Charles E. McQueary
Director
Operational Test and Evaluation

IOT&E Results: Effective, Suitable



DOT&E Priorities

1. Improve Suitability

2. Enhance operational realism in early tests

3. Provide timely performance information to the war fighters and fielding decision makers

4. Facilitate adequate OT resources

5. Ensure DOT&E personnel are well trained and prepared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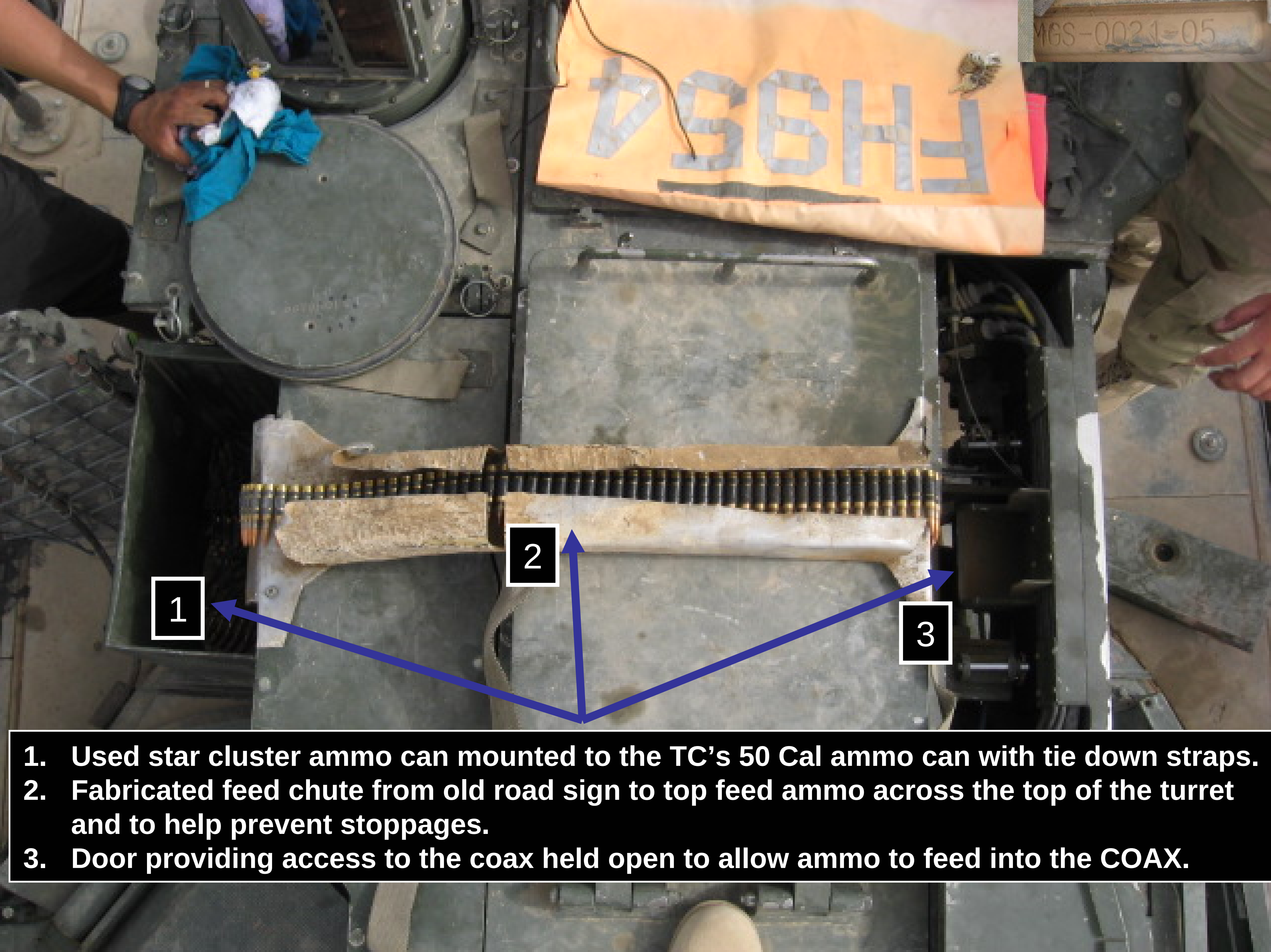
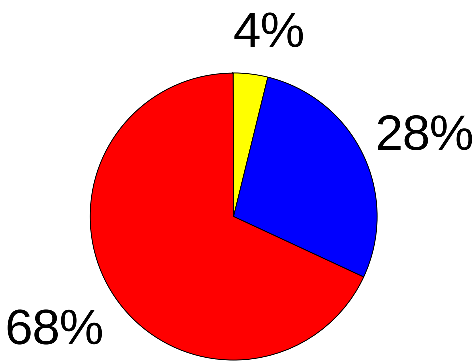


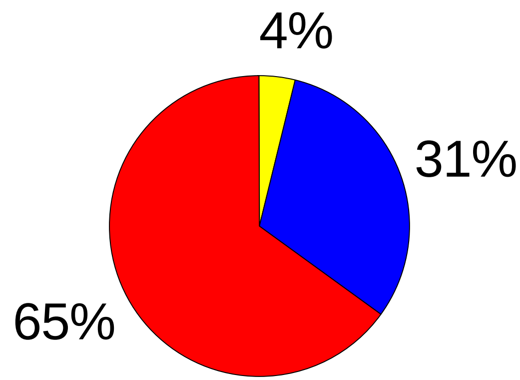
1. Used star cluster ammo can mounted to the TC's 50 Cal ammo can with tie down straps.
2. Fabricated feed chute from old road sign to top feed ammo across the top of the turret and to help prevent stoppages.
3. Door providing access to the coax held open to allow ammo to feed into the COAX.

DoD O&S Costs
Largest Fraction of Life Cycle Costs

Ground Combat Systems

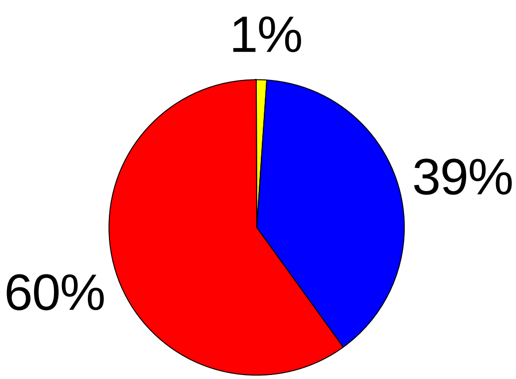


Rotary Wing Aircraft

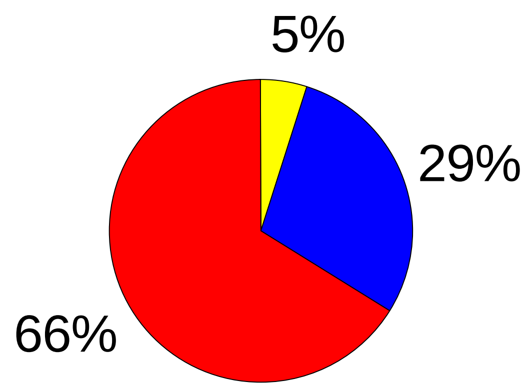


* Source: OSD CAIG

Surface Ships



Fighter Aircraft



RDT&E **Procurement** **O&S**

"We have a tendency to look at what it takes to get a program out the door. We don't think too much about what the life cycle [cost] is. It's 'Can I build it?' I would like us all to be mindful of what it costs to operate whatever we are building for whatever its life is going to be because I have to pay that bill every single year.“

(CNO, ADM Michael G. Mullen in an interview with "Government Executive" magazine May 15, 2006)

Logistics Management Institute Study
Reliability Investment RoI 5:1 to 128:1

Reliability Investment and Support Cost Reduction								
Case Study	MTBx Hours			* CASA 20-Year Support Cost (costs in FY03 M $, discounted 7%)			Economics (FY03 M $)	
	Was	Is	Percent Change	Was	Is	Percent Change	Reliability Investment	ROI
Predator	40	77	92.5%	$1,463	$576	60.6%	$39.1	22.7:1
Global Hawk	67.7	120	77.3%	$2,547	$1,958	23.1%	$121.9	5:1
FBCB2	47	364	674.5%	$13,060	$1,880	85.6%	$87.4	128:1

* CASA – Cost Analysis Strategy Assessment

- Reliability investments resulted in 20-yr support cost reductions
- Returns-on-Investment ranged from 5:1 to 128:1

Defense Logistics Agency Metrics
Reliability Investment RoI 15.5:1

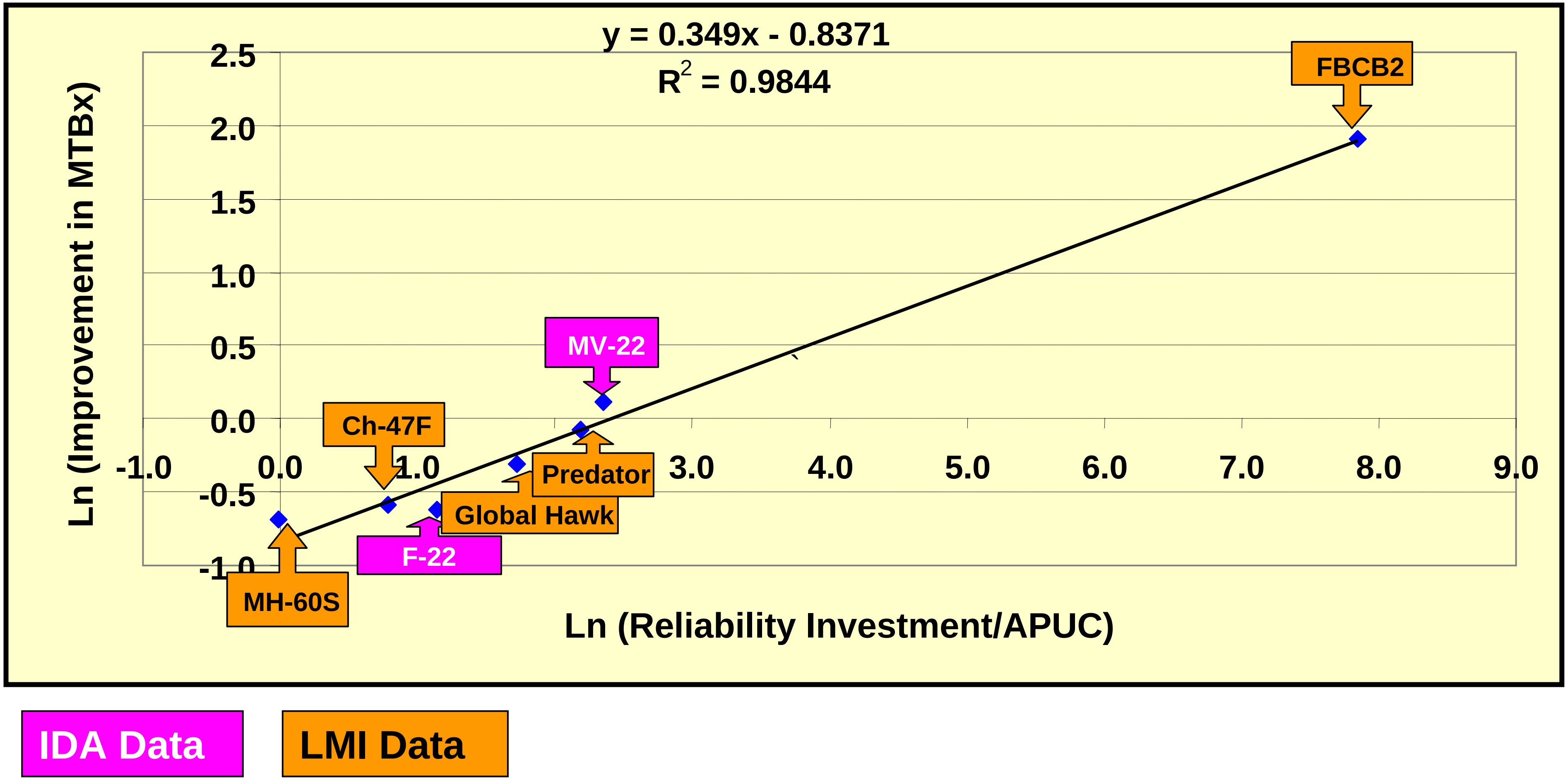
DLA Reliability Investment Summary			
Service	Investment ($M)	Estimated 10 year LC Savings ($M)	ROI
Army	14.1	187.0	13.3:1
Navy	9.7	207.0	21.3:1
Air Force	8.3	102.0	12.3:1
Total	32.1	496.0	15.5:1

Source: Karron Small, Aviation Engineering Directorate, Defense Supply Center Richmond, Nov 2005

Returns-on-Investment in reliability 15.5:1

Empirical Relationship

Reliability Investment & Reliability Growth



Areas That Need Engagement of SE Community

1. **Requirements**
   - Need to be fully understood so that a good reliability program can be characterized
   - Government must articulate the reliability requirements in RFPs or Request for Proposals, to provide both the incentive and understanding for industry
   - Industry must propose appropriate solutions; and then systems engineers and management must follow through with an appropriate design
2. **Reliability Objectives**
   - Need to be an integral part of the business strategy and have the commitment of senior management - and appropriate incentives must be in place
3. **Reliability tasks**
   - Must be an integral part of SE and addressed early in the design phase
4. **Operational-use-environment, Duty cycles, Related stresses**
   - Must be understood for the entire life cycle
5. **Root cause analysis of critical failure modes**
   - Must be done to eliminate or minimize their consequences
6. **Reliability of the design**
   - Should be verified by testing and analysis to ensure requirements are achieved

Actions to Improve Suitability

1. Key Performance Parameter (KPP) for Materiel Availability with two Key System Attributes (KSA) - Materiel Reliability and Ownership Costs
2. Sustainment Metrics Rationale Report
3. DoD Guide for Achieving Reliability, Availability, and Maintainability
4. Four new metrics for acquisition program oversight process
5. New industry based reliability program management standard
6. Standard data elements associated with the KPP and KSAs
7. Reliability training for select OSD staff
8. NDIA conference focusing on improving suitability
9. NDIA/DT&E committee proposing changes to improve suitability

OPERATIONAL TEST AND EVALUATION • DIRECTOR •

KEY TO

WEAPONS THAT

WORK

Joint Safety Review Process Study

10th Annual Systems Engineering Conference

23 October 07

Ms. Kristin Thompson
System Safety Engineer
thompson_kristin@bah.com

Agenda

- Background
- Phase I results
- Phase II efforts
- System Dependent vs. System Independent
- Results and Conclusions

Why Develop Service-Wide Safety Testing Standards?

- Moving forward, all weapons/ weapon systems will be developed as **joint systems** vis a vis JCIDS

- A joint approach promotes consistency and will get systems fielded sooner. Reduces (1) the overall number of tests, (2) time to fielding and (3) cost.

THE JOINT STAFF
WASHINGTON, D.C. 20318-8000

JOINT REQUIREMENTS OVERSIGHT COUNCIL

JROCM 102-05
20 May 2005

MEMORANDUM FOR: Vice Chief of Staff, US Army
Vice Chief of Naval Operations
Vice Chief of Staff, US Air Force
Assistant Commandant of the Marine Corps

Subject: Safe Weapons in Joint Warfighting Environments

1. The Joint Requirements Oversight Council (JROC) approved the establishment of a Joint Weapons Safety Technical Advisory Panel (JWSTAP) to advise the Deputy Director for Force Protection, J-8, on joint weapons safety issues. The JROC also approved the institution of a Safe Weapons in Joint Warfighting Environments endorsement within the Joint Capabilities Integration and Development System (JCIDS) vetting process, upon the development and approval of a JWSTAP charter. The Joint Staff, J-8, Protection Assessment Division will develop and coordinate the JWSTAP charter for joint approval.

2. Because all weapons/weapon systems have the potential of being deployed together or employed in joint environments, weapons and weapon systems will be considered joint systems within the JCIDS process unless they are assigned the Joint Potential Designator of "Independent".

PETER PACE
General, United States Marine Corps
Vice Chairman
of the Joint Chiefs of Staff

Copy to:
Under Secretary of Defense for Acquisition, Technology, and Logistics

Phase I Results

- Collected over 80 documents resulting in nearly 650 safety tests
  - Weapon/explosive testing only
  - MIL-STDs, STANAGs, ITOPs, TOPs, AECTPs
  - System-level and subsystem/component-level tests
  - Service-unique tests and tests common to more than one Service
  - Many of the tests identified are used for other purposes other than safety
- Documents and associated tests captured and categorized in a Microsoft Access database
  - Service, type of natural or induced environment that the test simulates, life cycle phase that the test simulates, system/component
- Phase I clearly indicates that there are potential savings to support a Phase II effort

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Phase I Results (cont'd)

- Joint Weapons Safety Technical Advisory Panel (JWSTAP), composed of all Service Safety Board Reps, agreed to use the following terms to define a mode of the weapon

Mode	Submode
PHS&T (Transportation)	Wheeled Land Vehicles Rail Fixed/Rotary Wing Aircraft Operational Navy Vessels Prepo/Merchant Marine/Commercial Undersea Man Carried
PHS&T (Packaging)	Prior to Gov't release After Gov't acceptance
PHS&T (Handling)	Forklift Hand cart Crane Man Carried Underway Replenishment (VERTREP and CONREP)
PHS&T (Storage)	Protected and/or Environmentally-Controlled Land Based Magazines Unprotected and/or Not Environmentally-Controlled Land Based Magazines
Employment	Tracked Land Vehicles Wheeled Land Vehicles Fixed Wing Aircraft Rotary Wing Aircraft Operational Navy Vessels Undersea Man Carried

Phase I Results (cont'd)

Mode Definitions

- **Packaging** – Configuration of item prior to transportation. Includes test requirements prior to government acceptance and repackaging requirements for shipping, e.g., Fleet Issue Unit Load
- **Handling*** – Applies to the use of devices, such as forklifts, hand carts, cranes, underway replenishment and man carried, for the breakout, lifting, or repositioning of ordnance or explosive devices in order to facilitate storage, assembly or disassembly, loading or downloading, or transporting.
- **Storage** – Placing ordnance or explosive devices in temporary (not to exceed 24 hours) and permanent land facilities that are either protected/ environmentally-controlled magazines or unprotected/open areas. This mode does not include storage on a ship.
- **Transportation*** – The capability of material to be moved by wheeled land vehicles, rail, fixed/wing aircraft, operational Navy vessels, prepo/merchant marine/commercial, undersea, and man carried
- **Employment*** – The strategic, operational or tactical use of weapons by tracked/wheeled land vehicles, fixed/rotary wing aircraft, operational Navy vessels, undersea, and man carried.

*Adapted from Joint Publication 1-02, Department of Defense Dictionary of Military and Associated Terms

Phase II Project Goals

- Draft JWSTAP Manual with Mode Checklist and Tests for each Check
  - Follow this manual to receive "safe weapons endorsement"
  - Manual will most likely refer to an existing standard. Deviations from existing standards will be documented in manual.
  - Manual will clarify any test discrepancies including passing criteria
- System-independent tests only
- Need to identify benefit (e.g., cost savings) resulting from common tests
- Substantiate value to examine system dependent tests

Phase II Effort

- Refine Data Collected
  - Add new database fields
  - Review tests for appropriate categorizations
- Identify Key Stakeholders
  - Service Board reps
  - Service-specific Subject Matter Experts (SMEs)
- Conduct Analysis on System-Independent Tests
  - Identify apparent duplicate, inconsistent and Service-specific tests
  - Interview SMEs to validate initial findings
- Host stakeholder workshops to obtain joint agreement on a standard list of safety tests by mode
- Prepare final documentation

Phase II End Products

- Input to CJCSM 3170
  - Defines modes
  - Provide draft language in manual for ICDs, CDDs, CPDs
- JWSTAP Report
  - Implementing guidance to CJCSM 3170 to include specific tests per mode
  - Rationale for implementing guidance
  - Contains details of Phase II effort
- Presentation
  - Results of Study
  - Summary of Report

Phase II End Products

- JWSTAP Report
  - Purpose
  - Outline

    Executive Summary

    1.0 Introduction

    2.0 Approach (Phase I and II)

    3.0 Definitions of Modes

    4.0 Tests

    5.0 Analysis of Tests

    6.0 Required Tests by Mode

    7.0 Proposed Language for JCIDS Documents

    8.0 Summary/Conclusions
- Presentation
  - Results of Study
  - Summary of Report

1.1 Background
1.2 Purpose
1.3 Scope
1.4 Assumptions

4.1 Test Documentation
4.2 Test Classification
4.3 System Independent vs. System Dependent

5.1 Test Class I
5.2 Test Class II
5.3 Test Class XXX

7.1 CJCSI 3170
7.2 CJCSM 3170
7.2.1 Appendix E (ICD)
7.2.2 Appendix F (CDD)
7.3 ICD
7.4 CDD

Phase II Report Outline

- Scope
  - Covers weapon and weapon container test procedures/requirements in all MIL-STDs, MIL-SPECs, STANAGs, ITOPs, AOPs
  - Does not cover any commercial standards, developmental tests, system-tailored documents, IM tests or AECTPs
  - Analysis covers system independent tests defined by established modes only
  - Tests were included as long as the test simulated an environment in one of the established modes
- Assumptions
  - Active standards are being used
  - All proposed required tests follow system-independent test documents
  - All weapons being transported by ship are in the “Transportation” mode; not the “Storage” mode
  - Assignment of test classifications, based upon test documentation, is accurate

The vision…

CD — A — B — C

Initial Capabilities Document → **Capabilities Development Document** → **Capabilities Production Document**

- PHS&T (Transportation)
  - Wheeled Land Vehicles
  - Rail
  - Fixed Wing Aircraft
  - Rotary Wing Aircraft
  - Operational Navy Vessels
  - Prepo/Merchant Marine/Commercial
  - Undersea
  - Man Carried
- PHS&T (Packaging)
  - Prior to Government Release
  - After Government Acceptance (Single/Bulk)
- PHS&T (Handling)
  - Forklift
  - Handcart
  - Crane
  - Man Carried
  - Underway Replenishment (VERTREP, CONREP)
- PHS&T (Storage)
  - Protected/Environmentally-Controlled Land Based Magazines
  - Unprotected/Open Land Based Magazines
- Employment
  - Tracked Land Vehicles
  - Wheeled Land Vehicles
  - Fixed Wing Aircraft
  - Rotary Wing Aircraft
  - Operational Navy Vessels
  - Undersea
  - Man Carried

Drives System Independent Tests

System Independent and Dependent Tests

1. **Joint** Shock Test
2. **Joint** Vibration Test
3. **Joint** Temperature Test
4. **Joint** EEE Test
5. …

Drives System Dependent Tests

- System, Subsystem, All
- System-Specific
- Ammunition
- Cannon
- Electric Initiators
- Explosives
- Fuze
- Power Sources
- Rocket Motors
- Software
- Submunitions
- Unmanned Targets

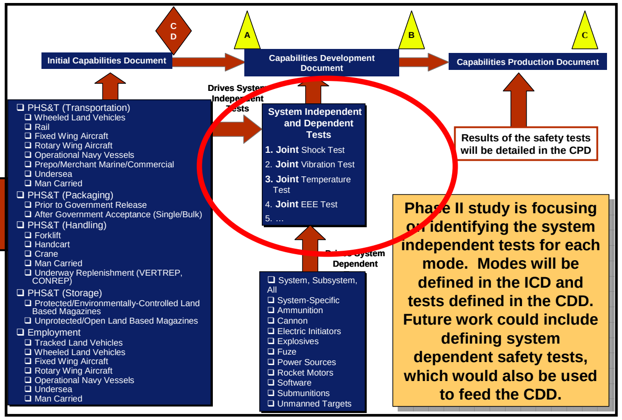
Results of the safety tests will be detailed in the CPD

Phase II study is focusing on identifying the system independent tests for each mode. Modes will be defined in the ICD and tests defined in the CDD. Future work could include defining system dependent safety tests, which would also be used to feed the CDD.

Required Tests

Test Classifications

- High/Low Temperature
- High/Low Pressure
- Contamination and Corrosion
- Shock and Temperature
- Temperature and Humidity
- Temperature/Shock/Humidity
- EEE
  - ESD
  - Lightning
  - EMI
  - HERO
- Shock
  - Short and Long Drops
  - Vibration
  - Shock/Vibration
  - Acoustic
  - Thermal
  - Pyro



Every System going through development will be required to do standard joint tests. There will be a test for each test classification.

System Independent vs. System Dependent

- System Independent
  - Certain tests you do regardless of what is in the weapon system.
  - Example: Shock, Drop, Vibration.
- System Dependent
  - Tests that are driven by specific components of a system.
  - Tests are more clearly defined once the system is mature.
  - Example: Fuze, Ammunition, Explosives.

Our findings show that Services use system-dependent tests for standard system independent tests.

System Independent Documents

Doc Type	TD Number	TD Name
49 CFR	178.6	Testing of Non-bulk Packagings and Packages
ITOP	1-2-511	Intersystem Electromagnetic Compatibility Requirements, System Testing
ITOP	4-2-601	Drop Tests for Munitions
ITOP	4-2-828	Ballistic Shock Testing
MIL-STD	461	Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment
MIL-STD	464	EEE Requirements for Systems
MIL-STD	648	Design Criteria for Specialized Shipping Containers
MIL-STD	810	Environmental Engineering Considerations
MIL-S	901	Shock Tests, High Impact Shipboard Machinery, Equipment, and Systems Requirements
STANAG	4239	Electrostatic Discharge Munitions Test Procedures
STANAG	4327	Lightning, Munition Assessment and Test Procedures
STANAG	4375	Safety Drop, Munition Test Procedure

We have reduced the number of documents from 86 to 12.

System Independent Tests by Test Classification

- Contamination & Corrosion - 6
- EEE - 40
- Icing - 1
- Impact - 5
- Leak (internal) - 5
- Lifting - 1
- Pressure – High - 2
- Pressure – Low - 1
- Shock - 4
- Shock – Acoustic - 2
- Shock – Mechanical - 3
- Shock – Pyro - 1
- Shock and Temperature - 2
- Shock/Vibration - 1
- Shock-Mechanical (long drop) - 6
- Shock-Mechanical (short drop) - 9
- Temperature – High - 3
- Temperature – Low - 1
- Temperature and Humidity - 1
- Temperature Shock Humidity - 1
- Tiedown - 2
- Vibration - 10

We have reduced the number of tests for analysis from 650 to 107.

Preliminary Findings

- JWSTAP members have little involvement with or knowledge of the test community
- Many active standards are not being used
  - No one that we have talked with are using AECTPs
  - Ratified STANAGs are not being used by US (e.g., STANAG 4239, Electrostatic Discharge Munitions Test Procedures)
  - There is a tendency not to use STANAGs at all
- System dependent tests are used for system independent tests
  - There is no system independent short drop tests
  - MIL-STD-464 ESD test refers to MIL-STD-331, a fuze standard

Preliminary Findings (cont'd)

- ESD Testing
  - When testing Helicopter Borne ESD, the Navy and Army have different test procedures. The Navy tests bare systems whereas the Army tests systems in a packaged configuration.
  - STANAG 4239, Electrostatic Discharge Munitions Test Procedures, is not the primary standard being used by the Services.
  - The Army uses inert EEDs for testing whereas the Navy uses live EEDs for testing. The Navy will not accept the Army's test results in these cases.
- Other EEE Testing
  - MIL-STD-461 tests are being used at the system/platform level rather than MIL-STD-464. Root issue is a standardize definition of "system."

Preliminary Findings (cont'd)

- Vibration
  - Some new programs develop Project Peculiar Documents (PPDs). The PPDs establish vibration requirements different from any MIL-STD or STANAG.
- Mechanical Drop
  - There is no standard short test being used by the Services.

Conclusions

- Defined approach and methodology to conduct analysis.
- Currently interviewing Stakeholders and SMEs to validate test data and test classifications.
- Preparing for facilitated meetings with Stakeholders and SMEs to gain consensus on standard joint tests.
- On track to prepare manual and outline of final report to be presented to the JWSTAP in Nov 07.
- Phase II project is completed by Feb 2008.

BACK-UP

System Independent Tests by Test Classification Contamination & Corrosion

P	H	S	T	E	Test Name	Test Number	Doc Type	TD Number
X	X	X	X	X	Acidic Atmosphere	Method 518	MIL-STD	810
X	X	X	X	X	Contamination by Fluids	Method 504	MIL-STD	810
		X			Fungus	Method 508.5	MIL-STD	810
		X	X	X	Salt Fog	Method 509.4	MIL-STD	810
X	X	X	X	X	Salt Fog Test	5.4.1	MIL-STD	648
		X-U			Sand and Dust	Method 510.4	MIL-STD	810

System Independent Tests by Test Classification EEE

P	H	S	T	E	Test Name	Test Number	Doc Type	TD Number
				X	Conducted Emissions, Antenna Terminal 10khz to 40ghz	CE106	MIL-STD	461
				X	Conducted Emissions, Power Leads 10khz to 10mhz	CE102	MIL-STD	461
				X	Conducted Emissions, Power Leads 30hz to 10khz	CE101	MIL-STD	461
				X	Conducted Susceptibility, Antenna Port Rejection of Undesired Signals 30hz to 20ghz	CS104	MIL-STD	461
				X	Conducted Susceptibility, Antenna Port, Cross Modulation 30hz to 20ghz	CS105	MIL-STD	461
				X	Conducted Susceptibility, Antenna Port, Intermodulation 15khz to 10ghz	CS103	MIL-STD	461
				X	Conducted Susceptibility, Bulk Cable Injection 10khz to 200mhz	CS114	MIL-STD	461
				X	Conducted Susceptibility, Bulk Cable Injection, Impulse Excitation	CS115	MIL-STD	461
				X	Conducted Susceptibility, Damped Sinusoidal Trans Cables and Power Leads, 10 kHz to 100 MHz.	CS116	MIL-STD	461
				X	Conducted Susceptibility, Power Leads 30hz to 150 kHz	CS101	MIL-STD	461
				X	Conducted Susceptibility, Structure Current	CS109	MIL-STD	461
				X	Electrical Bonding	5.1	MIL-STD	464
		X			Electromagnetic Pulse (EMP)	5.5	MIL-STD	464
X	X	X	X	X	Electromagnetic Radiation Hazards (EMRADHAZ)	5.8	MIL-STD	464
	X-MC		X-RWA	X-MC&RWA	Electrostatic Discharge (Personnel and Helicopter)	A-1	STANAG	4239

System Independent Tests by Test Classification EEE (cont'd)

P	H	S	T	E	Test Name	Test Number	Doc Type	TD Number
X	X	X	X	X	Emission Control (EMCON)	5.13	MIL-STD	464
X	X	X	X	X	EMRH	2.1	TOP	1-2-511
X	X	X	X	X	EMRO	2.2	TOP	1-2-511
	X	X	X	X	Evaluation of the Hazards Caused By Shock Excitation and Ground Voltage Transients	B-2-1	STANAG	4327
	X	X	X	X	Explosives and Fuel Hazards Assessment	B-3-1	STANAG	4327
X	X	X	X	X	External Ground	5.11	MIL-STD	464
				X	External RF EME	5.3	MIL-STD	464
	X	X	X	X	Group IV Test Methods	C-7-1	STANAG	4327
				X	Intra-System Electromagnetic Compatibility (EMC)	5.2	MIL-STD	464
	X	X	X	X	Lightning Test Method	C-1	STANAG	4327
	X	X	X	X	Lightning Test Waveforms for use with the Test Methods Given in Appendices C1-C7	B-4-1	STANAG	4327
	X	X	X	X	Methods for Detecting Sparking	C-8-1	STANAG	4327
				X	Radiated Emissions Magnetic Field	RE101	MIL-STD	461
				X	Radiated Emissions, Antenna Spurious & Harmonic	RE103	MIL-STD	461
				X	Radiated Emissions, Electric Field	RE102	MIL-STD	461
				X	Radiated Susceptibility, Electric Field	RS103	MIL-STD	461
				X	Radiated Susceptibility, Magnetic Field	RS101	MIL-STD	461
				X	Radiated Susceptibility, Transient Electromagnetic	RS105	MIL-STD	461

System Independent Tests by Test Classification EEE (cont'd)

P	H	S	T	E	Test Name	Test Number	Doc Type	TD Number
	X	X	X	X	Requirements for Energetic Material Hazard Assessment Tests-Solid Explosives	C-4-1	STANAG	4327
	X	X	X	X	Requirements for Equipment	C-3-1	STANAG	4327
	X	X	X	X	Requirements for Group II Tests on Parts of Weapon	C-2-1	STANAG	4327
	X	X	X	X	Requirements for Group II Tests on Whole Weapons	C-1-1	STANAG	4327
X	X	X	X	X	Static Electricity Hazard	2.1	TOP	1-2-511
X	X	X	X	X	Static Electricity Operational	2.2	TOP	1-2-511
				X	Subsystems and Equipment Electromagnetic Interference (EMI)	5.6	MIL-STD	464

System Independent Tests by Test Classification
Icing, Impact, Leak (internal), Lifting

P	H	S	T	E	Test Classification	Test Name	Test Number	Doc Type	TD Number
				X	Icing	Icing/Freezing Rain	Method 521.2	MIL-STD	810
			X-Rail		Impact	Impact Test (stacked)	5.2.7.1	MIL-STD	648
	X				Impact	Incline-Impact	Appendix L	MIL-STD	648
	X				Impact	Pendulum Impact Test	5.2.7	MIL-STD	648
	X		X		Impact	Rollover Test	Appendix K	MIL-STD	648
			X		Impact	Stacking Test	178.606	49 CFR	178.6
				X	Leak (internal)	Explosive Atmosphere	Method 511.4	MIL-STD	810
		X		X	Leak (internal)	Immersion	Method 512.4	MIL-STD	810
			X		Leak (internal)	Leak Proofness Test	178.604	49 CFR	178.6
	X		X		Leak (internal)	Leak Test	5.6.2	MIL-STD	648
X	X	X	X	X	Leak (internal)	Rain	Method 506.4	MIL-STD	810
	X-Forklift				Lifting	Forklift Truck (Fully Captive Fork Tine Enclosures) Compatibility Test	5.9	MIL-STD	648

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System Independent Tests by Test Classification
Pressure, Shock, Shock and Temp, Shock/Vibration

P	H	S	T	E	Test Classification	Test Name	Test Number	Doc Type	TD Number
			X		Pressure – High	Hydrostatic Pressure Test	178.605	49 CFR	178.6
	X				Pressure – High	Pressure test	5.5.2	MIL-STD	648
		X	X	X	Pressure – Low	Low Pressure (Altitude)	Method 500.4	MIL-STD	810
			X-ONV	X	Shock	Heavy Weight Shock	3.1.2c	MIL-S	901
			X-ONV	X	Shock	Light Weight Shock	3.1.2a	MIL-S	901
			X-ONV	X	Shock	Medium Weight Shock	3.1.2b	MIL-S	901
		X		X	Shock	Shipboard Shock Test	5.2.9	MIL-STD	648
				X	Shock – Acoustic	Acoustic Noise	Method 515.5	MIL-STD	810
				X	Shock – Acoustic	Ballistic Shock	4	ITOP	4-2-828
			X	X	Shock – Mechanical	Acceleration	Method 513.5	MIL-STD	810
			X	X	Shock – Mechanical	Ballistic Shock	Method 522	MIL-STD	810
	X		X	X	Shock – Mechanical	Shock	Method 516.5	MIL-STD	810
			X	X	Shock – Pyro	Pyroshock	Method 517	MIL-STD	810
X	X	X	X	X	Shock and Temperature	Temperature Shock	Method 503.4	MIL-STD	810
			X		Shock and Temperature	Vibro-Acoustic/Temperature	Method 523.2	MIL-STD	810
				X	Shock/Vibration	Gunfire Vibration	Method 519.5	MIL-STD	810

System Independent Tests by Test Classification Shock-Mechanical (long and short drops)

P	H	S	T	E	Test Classification	Test Name	Test Number	Doc Type	TD Number
	X				Shock-Mechanical (long drop)	Drop	8a	STANAG	4375
	X				Shock-Mechanical (long drop)	Safety drop test	5.2.10	MIL-STD	648
	X				Shock-Mechanical (long drop)	Simulated High Velocity Parachute Drop	4.4	ITOP	4-2-601
	X				Shock-Mechanical (long drop)	Simulated Low Velocity Parachute Drop	4.3	ITOP	4-2-601
	X				Shock-Mechanical (long drop)	Twelve Meter Drop	4.1	ITOP	4-2-601
	X				Shock-Mechanical (short drop)	Cornerwise-drop (rotational) test (12-15 in drop)	5.2.4	MIL-STD	648
			X		Shock-Mechanical (short drop)	Drop Test	178.603	49 CFR	178.6
X	X	X	X	X	Shock-Mechanical (short drop)	Drop Test (free fall)	5.2.3	MIL-STD	648
X	X	X	X	X	Shock-Mechanical (short drop)	Edgewise-drop (rotational) Test	5.2.5	MIL-STD	648
	X				Shock-Mechanical (short drop)	Mechanical Handling Test	Appendix P	MIL-STD	648
	X		X		Shock-Mechanical (short drop)	Shock Test	5.10.3	MIL-STD	648
	X				Shock-Mechanical (short drop)	Three Meter Drop	4.2	ITOP	4-2-601
	X				Shock-Mechanical (short drop)	Tipover test	5.2.6	MIL-STD	648
	X-UR				Shock-Mechanical (short drop)	Transfer-at-sea Shock Test	5.2.8	MIL-STD	648

System Independent Tests by Test Classification
Temp, Temp and Humidity, Temp-Shock-Humidity, Tiedown, Vibration

P	H	S	T	E	Test Classification	Test Name	Test Number	Doc Type	TD Number
		X			Temperature – High	Fire test, external source.	5.11	MIL-STD	648
X	X	X	X	X	Temperature – High	High Temperature	Method 501.4	MIL-STD	810
		X-U			Temperature – High	Solar Radiation (Sunshine)	Method 505.4	MIL-STD	810
		X		X	Temperature – Low	Low Temperature	Method 502.4	MIL-STD	810
		X		X	Temperature and Humidity	Humidity	Method 507.4	MIL-STD	810
			X-A		Temperature Shock Humidity	Temperature, Humidity, Vibration and Altitude	Method 520.2	MIL-STD	810
			X-Road		Tiedown	Hoisting Fitting and Tiedown Attachment Points	5.8	MIL-STD	648
			X-Road		Tiedown	Tiedown Strength Test	5.8.4	MIL-STD	648
		X		X	Vibration	Endurance	5.2.1.4.6	MIL-STD	167-1
		X		X	Vibration	Endurance Test for Mast Mounted Equipment	5.1.2.4.7	MIL-STD	167-1
		X		X	Vibration	Exploratory Vibration	5.1.2.4.2	MIL-STD	167-1
X	X	X	X	X	Vibration	Random Vibration	5.3.4	MIL-STD	648
			X		Vibration	Repetitive Shock Test	5.2.2	MIL-STD	648
			X		Vibration	Repetitive Shock Test (stacked)	5.2.2.1	MIL-STD	648
		X			Vibration	Variable Frequency	5.1.2.4.3	MIL-STD	167-1
			X		Vibration	Vibration	178.608	49 CFR	178.6
	X		X		Vibration	Vibration	5.3	MIL-STD	648
X	X	X	X	X	Vibration	Vibration	Method 514.5	MIL-STD	810

Systems and Software Engineering Overview

October 23, 2007

Mark D. Schaeffer
Director, Systems and Software Engineering
Office of the Deputy Under Secretary of Defense (A&T)

Version 0.9

SE Challenges …circa 2003

- Lack of Uniform SE Understanding at Department level
  - Policy, implementation, incentives, product/process balance, life-cycle focus
- Lack of Uniform Understanding of SE in the Community-at-Large
  - Scope of SE, understanding of how to implement SE, what makes a good systems engineer, alignment of management and SE processes, multiple standards and models, alignment of practitioner communities
- Increasing system complexity
  - Integrated systems … higher levels of integration
- SE Resources – "We have a pipeline problem"

Our Challenge: Execute the "Big Picture"

DoD Systems Engineering Response

- USD(AT&L) Imperatives
  - Provide a context for decisions on individual programs
  - Achieve credibility and effectiveness in acquisition and logistics support processes
  - Help drive good SE practices back in how we do business
- Organizational response: new SE organization
  - Institutionalize SE across the Department
  - Set implementation policy, capture best practices, standards for Education and Training
  - Emphasis on system assessment and support

What We Have Done To Revitalize Systems Engineering 2003 - Today

- Issued DoD-wide SE policy – focused effort on up front, sound technical planning; issued safety policy
- Issued guidance on Systems Engineering, test and evaluation (T&E), software, and safety
- Worked with Defense Acquisition University to revise Systems Engineering curricula -- currently revising T&E and enabling career fields curricula
- Established Systems Engineering and Software Forum—senior-level focus within DoD
- Integrated development testing, software/system assurance, system of systems, and open systems into revitalization efforts
- Instituting a renewed emphasis on modeling and simulation
- Leveraging closer working relationships with industry and academia
- Instituting system-level assessments in support of OSD major acquisition program oversight role

System Engineering Revitalization Effort

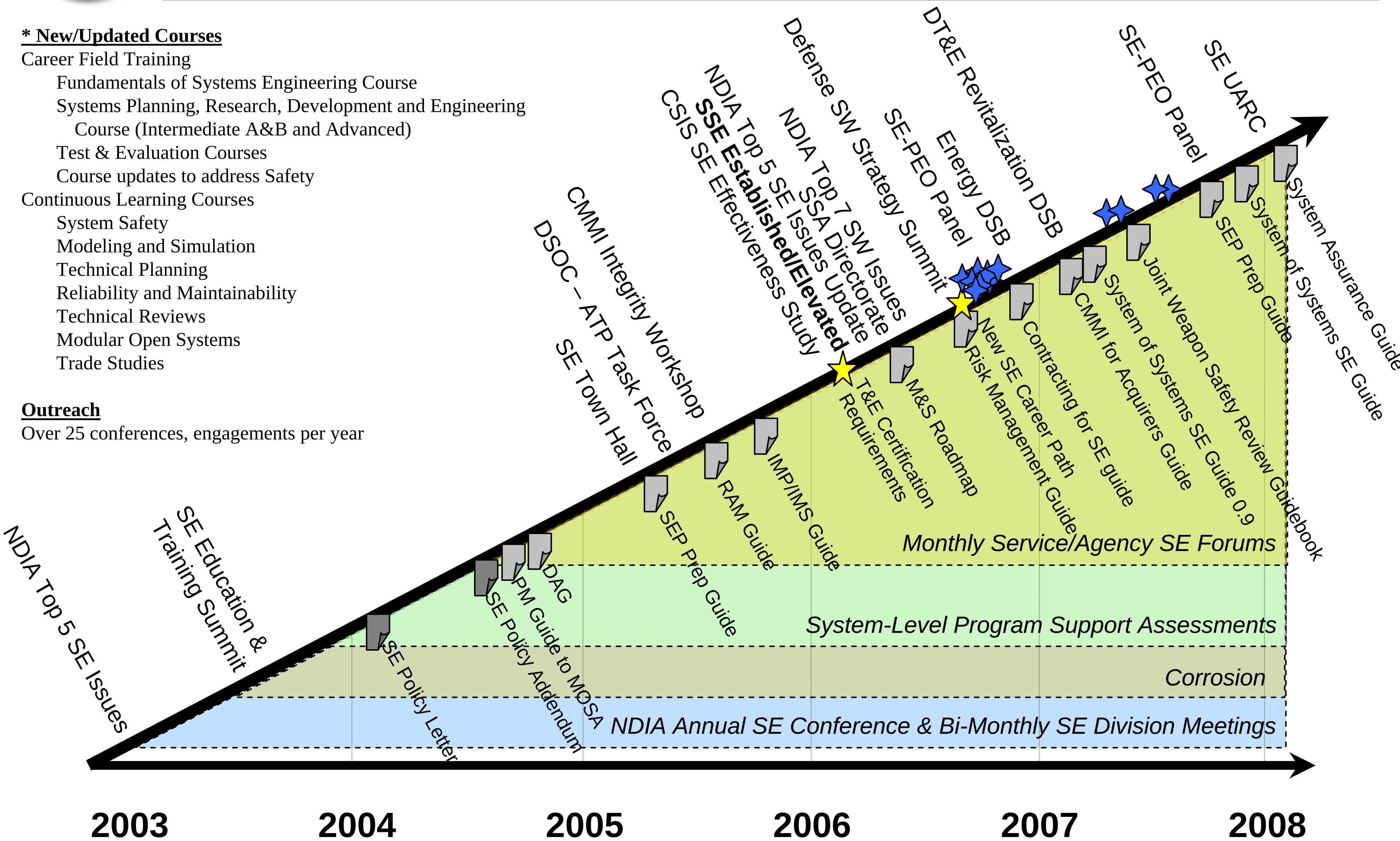
<u>* New/Updated Courses</u>

Career Field Training
- Fundamentals of Systems Engineering Course
- Systems Planning, Research, Development and Engineering Course (Intermediate A&B and Advanced)
- Test & Evaluation Courses
- Course updates to address Safety

Continuous Learning Courses
- System Safety
- Modeling and Simulation
- Technical Planning
- Reliability and Maintainability
- Technical Reviews
- Modular Open Systems
- Trade Studies

<u>Outreach</u>

Over 25 conferences, engagements per year



Current State of DoD Systems Engineering

- We have revitalized Systems Engineering Policy, Guidance, Education and Training…
- We have driven good systems engineering practices back into the way the acquisition community does business, and have had a positive impact on programs…
- We have expanded the boundaries to include increasingly important enablers for sound SE application…
- We have a rigorous process to capture what went wrong...
- …**but failed to change,** root cause behavior that leads to programs that do not meet cost, schedule, and performance expectations…adequate maturity at program initiation

Much Accomplished – Much to Do!

NDIA 10th Annual Systems Engineering Conference
OSD and Services Chief Engineer Panel

23 October 2007

Mr. Carl R. Siel, Jr.
ASN(RDA) Chief Systems Engineer
carl.siel@navy.mil

Topics

- Current Challenges
- Progress
- Emergent Challenges

Department of Navy Challenges

RDA CHIEF SYSTEMS ENGINEER

- Reverse erosion of domain knowledge within DoN
- Increase our knowledge of the shipbuilding process
  - *"…understand how to integrate design and production technology into an acquisition process that industry can execute."*
- Establish a deep knowledge of systems engineering and a profound understanding of acquisition process
  - *"Systems engineering is key to ensuring that each ship is configured to optimize the fleet.*
  - *The Navy does not fight a ship by itself. It wages war as part of an Expeditionary Strike Group or a Carrier Strike Group.*
  - *And those strike group formations are part of even larger Joint operations.*
  - *All this implies a need for integration of elements and capabilities."*

(Adapted from SECNAV speech to the Sea Air Space Exposition on 3 April 2007)

DoN Systems Engineering Hierarchy

RDA CHIEF SYSTEMS ENGINEER

Mission

Force Focused

System of Systems

Net Centric Integration

Platform Integration

Capability Focused

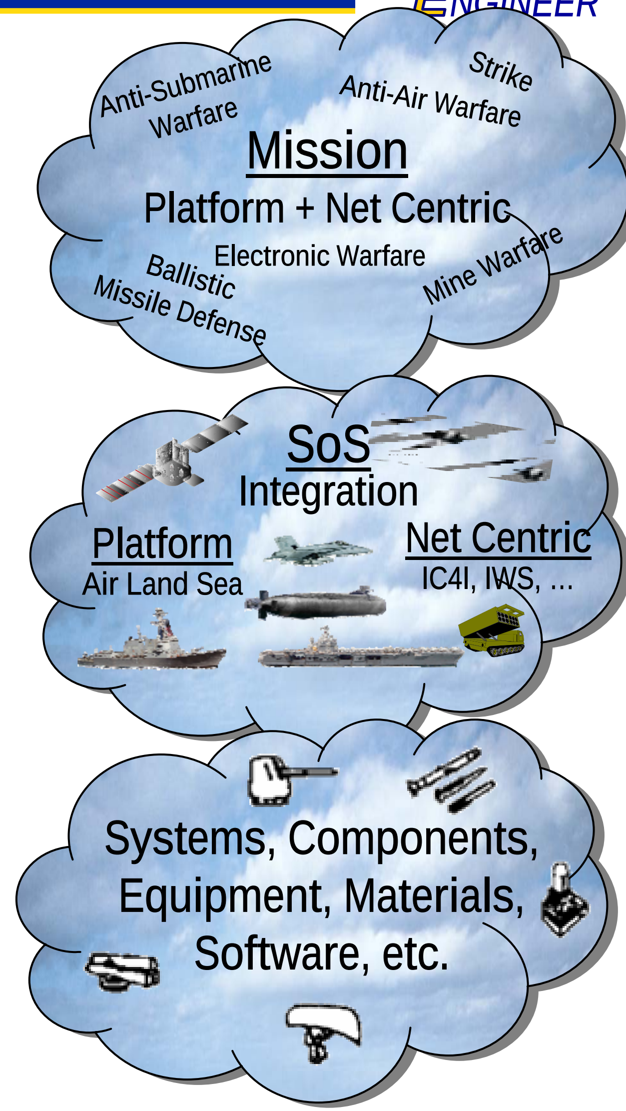
Systems and Components

Design, Build, Test Focused

Translates Operational Concepts → Capabilities

Translates Capabilities → System Requirements

Translates System Requirements → End Items



Must consider the Hierarchy and DOTMLPF over Time

Steps to Address Challenges

RDA CHIEF SYSTEMS ENGINEER

- Navy must re-assert its control over the entire acquisition process
  - *"Control over the process means that the Navy must make the selections of key trade-offs – performance, crew size, logistics support, cost, and schedule.*
  - *Added to that consideration is the fact that ships do not operate in isolation - - they operate with shore and air components.*
  - *These other factors are highly relevant, so it is very important that the Navy take all factors into consideration and exercise control over the decision process."*
- The Navy must define the design constraints to optimize the overall capability of the Fleet
  - *"…it is the Navy's responsibility to optimize the fleet's capabilities.*
  - *Such optimization might include common standards; preferred components and subsystems; mission modularity; and open architecture."*

(Adapted from SECNAV speech to the Sea Air Space Exposition on 3 April 2007)

Progress

RDA CHIEF SYSTEMS ENGINEER

- People, Process, Tools, Standards
  - Exercising Mission Level - Systems of Systems Engineering
    - Mine Warfare and Anti Submarine Warfare Missions
  - Systems Engineering Technical Review Process
    - Consolidating into a comprehensive process
    - Alignment of System Engineering Plans
    - Increased management of technical standards
    - Technical Authority and Competency Alignment
  - Systems Engineering Competencies
    - Personnel Knowledge, Skills, and Abilities (KSA)
    - Education, Training, and Experience
    - Air, Sea, Land, and Net-Centric Mission Systems
- PR 09 Systems Engineering Revitalization
  - $ 150 M increase over FY 09 – 13
    - Enhance People, Process, Tools, and Standards

Emergent Challenges

RDA CHIEF SYSTEMS ENGINEER

- Securing and Assuring the "System"
  - Protecting Program and Operational Information
  - Maintaining confidence in our Products
    - Network and Software Vulnerabilities
    - Information Security and Assurance
    - Anti-Tamper – Re Engineering
  - Safe and Assured Operations
    - Weapon Safety
    - Air Worthiness and Safety of Flight
    - Submarine Safety
    - Surface Ship Certification
    - Information Security and Assurance
  - Prevent the Loss of Life and Property

Consumers – Suppliers – Users are part of the Equation

SE View from Army
23 October 2007

Douglas K. Wiltsie
Assistant Deputy
Acquisition and Systems Management
Office of the Assistant Secretary of the Army
Acquisition Logistics and Technology

Sec. Bolton’s Challenges

- Systems Engineering:
  - Does not help us politically
  - Does not stabilize funding
  - Does not belong in the Requirements Process
  - Does not clearly address System of Systems

Army System Engineering Policy

The **Army System Engineering** program and policy approved (13 June 2005)

- Requires a SEP for each program
- Establishes a System Engineer within each program and PEO
- Establishes Army System Engineering Forum (ASEF)
- Establishes peer review at all major technical reviews
- Establishes the PEO as the SEP approval authority

DEPARTMENT OF THE ARMY
OFFICE OF THE ASSISTANT SECRETARY OF THE ARMY
ACQUISITION LOGISTICS AND TECHNOLOGY
103 ARMY PENTAGON
WASHINGTON D.C. 20310-0103

JUN 13 2005

SAAL-SSI

MEMORANDUM FOR PROGRAM EXECUTIVE OFFICERS
DIRECT REPORTING PROJECT MANAGERS

SUBJECT: Army Systems Engineering Policy

The Under Secretary of Defense for Acquisition, Technology and Logistics issued policy to reinvigorate systems engineering within the Department of Defense. Guidance for implementing systems engineering across Army Acquisition, Logistics and Technology is enclosed.

The Assistant Deputy for Acquisition and Systems Management, Office of the Assistant Secretary of the Army for Acquisition, Logistics and Technology, will chair an Army Systems Engineering Forum (ASEF) that is chartered to institutionalize effective systems engineering practices across our workforce and programs, and to promote collaboration across our requirements, acquisition, logistics, and testing communities. Each Program Executive Officer and Direct Reporting Program Manager is to designate a Chief System Engineer to participate on the ASEF. I expect the ASEF to plan, coordinate, manage, and execute initiatives for the resurgence of effective systems engineering, balancing programmatic cost, schedule, and supportability with technical reality. Within two weeks, please provide the name of your Chief System Engineer to Dr. James Linnehan, SAAL-SSI, (703) 604-7430, or e-mail: james.linnehan@saalt.army.mil.

Systems engineering excellence can integrate all elements of our U.S. Army community into a process driven disciplined team, producing timely, affordable, high quality products meeting the needs of our warfighters. I look forward to working with you to make this vision a reality and compelling success.

Claude M. Bolton, Jr.
Assistant Secretary of the Army
(Acquisition, Logistics and Technology)

Enclosure

CF:
USD(AT&L)
CG, AMC
CG, TRADOC

Current Focus

- System Engineering is being done in Army programs; we need to ensure that it is consistent and **consistently followed** across the PEOs
- Training is widely available but standards need to be established; we need to identify what's available and tailor to PEO/PM needs
- Requirements are done outside of the SE process; engage TRADOC on C4ISR and BC migration and identify new processes for SoS development
- Integrate Science and Technology into Systems Engineering revitalization
- Investigate establishment of a SoS Eng and Architecture Organization

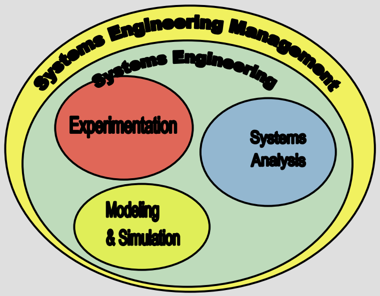
Capability Based Acquisition

Army is transitioning to more and more Capability Based acquisition.

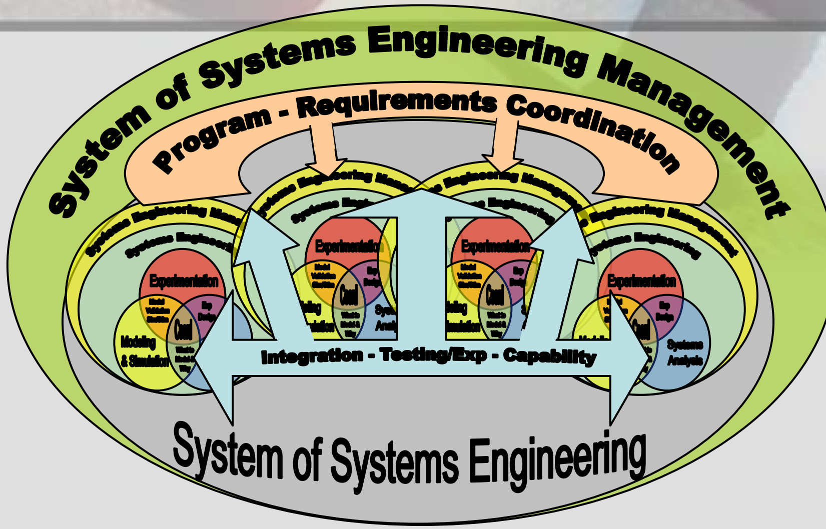
- Software blocking – Ensures end to end operability for all current and future battle command
- Future Combat System- 1st Army System of Systems capability based acquisition focused on developing and procuring a brigade level set of equipment
- Army Missile and Space – Develops the requirements and products to provide Air and Missile Defense capability
- Joint Network Node (JNN) to Warfighter Information Network-Tactical (WIN-T) – Current AOR network interoperability with future network.
- **Counter rocket and mortar – continual evolution of requirements**
- **Counter Improvised Explosive Devices – evolving/changing requirements and environments.**
- **Force Protection - continual evolution of requirements**
- **Battle Command – transition from current to future battle command capabilities**

Introduction: The Paradigm Shift

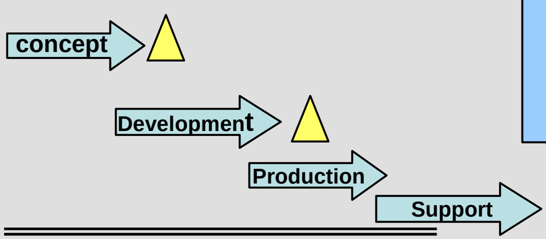
Well Bounded System



"MEGA SYSTEM"

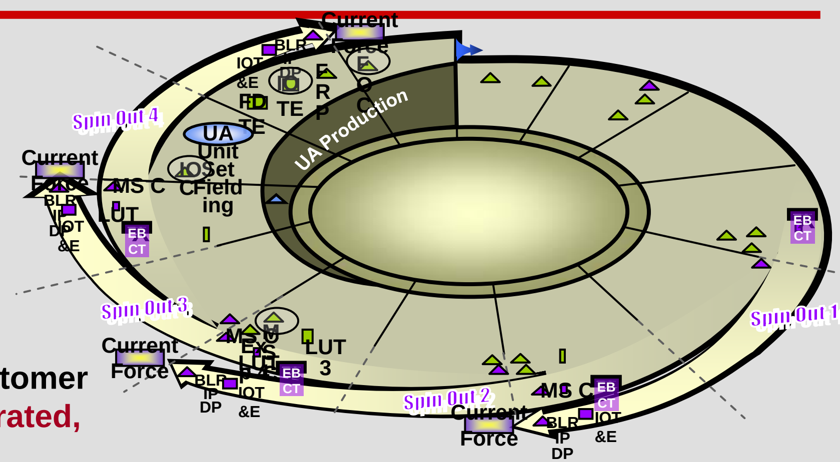


<u>**Must Change**</u>
Perspective
Boundaries
Process
People (KSAs)
Tools



Year 1

Year 8



Transform to provide multiple innovative overmatching capability options to the customer
Evolve supporting processes into an integrated, cross commodity, cross community SOS environment.

Delivery of Right Capabilities on Schedule on Budget

Requirements Generation

Goal: To Integrate SE into the Requirements Development Process, Especially for Complex Interdependent Programs

- Establish methods to support requirements generation at the System of Systems or Enterprise Level and help define the trade space
  - ASA(ALT)/TRADOC Capability Engineering Framework (CEF) Initiative for engineering the requirements/acquisition interface
  - Program Execution Working Group for cross PEO/TRADOC SE for C4ISR migration
  - Software Blocking
  - Ground Soldier System minimum essential capability
- Stepping stone to Joint System of Systems requirements
  - Generation Process (e.g. SIAP, SIGP, JBMC2, NCOE)
  - Without Joint Level overarching requirements, System Level requirements could be met and still not meet Joint Requirements

Army Strategic S/W Improvement Program

Goal: To dramatically improve the acquisition of software intensive systems

Objectives:

- Foster migration to a model-based system and software acquisition process improvement
- Institutionalize broad-based oversight, management, and technical expertise
- Apply an integrated system and software engineering approach to programs and improvement
- Systematically incorporate lessons learned, best practices, and new technology into policies, practices and processes